Total Maximum Daily Load

For

Turnback Creek and Tributary to Goose Creek

Lawrence and Dade Counties

303(d) Listing: *Escherichia coli* Bacteria

Submitted: October 20, 2021
Approved: March 8, 2022

Prepared by: Water Protection Program, Watershed Protection Section

WATER BODY SUMMARY
Total Maximum Daily Loads (TMDL) for Turnback Creek and Tributary to Goose Creek
303(d) Listing: *Escherichia coli (E. coli)* Bacteria

Water Body Identification (WBID), Hydrologic Class, and TMDL Development Prioritization:[1]

Turnback Creek	1414	Class P	High Priority
Tributary to Goose Creek	1420	Class C	High Priority


Location of watershed in Missouri

Location: Lawrence and Dade Counties

8-digit Hydrologic Unit Code (HUC):[2]
10290106 – Sac River

12-digit HUC Subwatersheds
102901060101 – Goose Creek
102901060102 – Headwaters Turnback Creek
102901060103 – Billie Creek - Turnback Creek
102901060105 – Sycamore Branch - Turnback Creek

Designated Uses:[3]
Irrigation
Livestock and wildlife protection
Human health protection
Protection and propagation of fish, shellfish, and wildlife
- Warm water habitat
- Cold water habitat (Turnback Creek)

Recreation in and on the water
- Whole body contact recreation category A (Turnback Creek)
- Whole body contact recreation category B (Tributary to Goose Creek)
- Secondary contact recreation

Impaired Uses:
Whole body contact recreation category A, Turnback Creek
Whole body contact recreation category B, Tributary to Goose Creek

Pollutant Identified on the 2020 303(d) List:
Escherichia coli (E. coli) (fecal indicator bacteria)

Identified Sources on the 2020 303(d) List:
Rural nonpoint sources

Length and Location of Impaired Segments:
WBID 1414: 19.9 miles, from Section 35, Township 30N, Range 26W to Section 24 Township 28N, Range 25W
WBID 1420: 3.0 miles, from mouth to Section 18, Township 28N, Range 25W

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[1] For hydrologic classes see 10 CSR 20-7.031(1)(F). Class P streams maintain permanent flow even in drought periods.

[2] Watersheds are delineated by the U.S. Geological Survey using a nationwide system based on surface hydrologic features. This system divides the country into 2,270 8-digit hydrologic units (USGS 2019). A hydrologic unit is a drainage area delineated to nest in a multilevel, hierarchical drainage system. A hydrologic unit code is the numerical identifier of a specific hydrologic unit consisting of a 2-digit sequence for each specific level within the delineation hierarchy (FGDC 2003).

[3] For designated uses see 10 CSR 20-7.031(1)(C) and 10 CSR 20-7.031 Table H. Presumed uses are assigned per 10 CSR 20-7.031(2)(A) and (B) and are reflected in the Missouri Use Designation Dataset described at 10 CSR 20-7.031(2)(E).

Table of Contents

Figures

Tables

1. Introduction

In accordance with Section 303(d) of the federal Clean Water Act, the Missouri Department of Natural Resources is establishing total maximum daily loads (TMDLs) to address elevated concentrations of *Escherichia coli* (*E. coli*) bacteria in Turnback Creek and Tributary to Goose Creek located in Lawrence and Dade Counties. This TMDL report addresses two water quality limited segments that are on Missouri's 2020 303(d) List of Impaired Waters due to exceedances of Missouri's *E. coli* bacteria criteria.[4] These listings were approved by the U.S. Environmental Protection Agency (EPA) on November 30, 2020.[5]

Section 303(d) of the federal Clean Water Act and Title 40 of the Code of Federal Regulations (CFR) Part 130 require states to develop TMDLs for waters that do not meet applicable water quality standards. Missouri's Water Quality Standards at Title 10 of the Code of State Regulations (CSR) Division 20 Chapter 7, Rule 0.31 consist of three major components: designated uses, water quality criteria to protect those uses, and an antidegradation policy. A TMDL is equal to the loading capacity of a water body for a specific pollutant and represents the maximum amount of a pollutant that a water body can assimilate and still attain and maintain water quality standards. The *E. coli* bacteria loading capacities for each water body are derived from the maximum *E. coli* concentration allowed by Missouri's Water Quality Standards and are translated to mass loads using stream flow under all recorded conditions. Once the loading capacity of a water body has been quantified, existing and future point sources and nonpoint sources are assessed for their potential to contribute the pollutants of concern. In accordance with 40 CFR 130.2, contributing point sources are assigned a portion of the available loading capacity as a wasteload allocation and nonpoint sources are assigned a load allocation. In accordance with federal Clean Water Act section 303(d)(1)(C), a margin of safety is also included. Margins of safety can be explicit (numeric) or implicit (qualitative) to account for any lack of knowledge concerning the relationship between pollutant loading and water quality, uncertainty associated with the model assumptions, or data inadequacies (40 CFR 130.7). The TMDL for any given pollutant is the sum of the wasteload allocation, the load allocation, and the margin of safety.

2. Watershed Description

Turnback Creek and Tributary to Goose Creek are located in southwest Missouri within the Sac River subbasin, which is cataloged by the U.S. Geological Survey (USGS) as the 8-digit hydrologic unit code (HUC) 10290106. Within this subbasin, the 19.9-mile impaired segment of Turnback Creek (WBID 1414) receives runoff from a 135.4 square mile watershed comprised of three 12-digit HUC watersheds (102901060101, 102901060102, 102901060103) plus 46 percent of 12-digit HUC 102901060105. The impaired 3-mile Tributary to Goose Creek (WBID 1420) receives runoff from a 4.75 square mile area within 12-digit HUC watershed 102901060101. Figure 1 displays the Turnback Creek and Tributary to Goose Creek watersheds.

[4] A water quality limited segment is any segment where it is known that water quality does not meet applicable water quality standards, or is not expected to meet applicable water quality standards, even after the application of the technology-based effluent limitations required by sections 301(b) and 306 of the federal Clean Water Act (40 CFR 130.2).

[5] The Department maintains current and past 303(d) lists and corresponding assessment worksheets online at dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/impaired-waters.

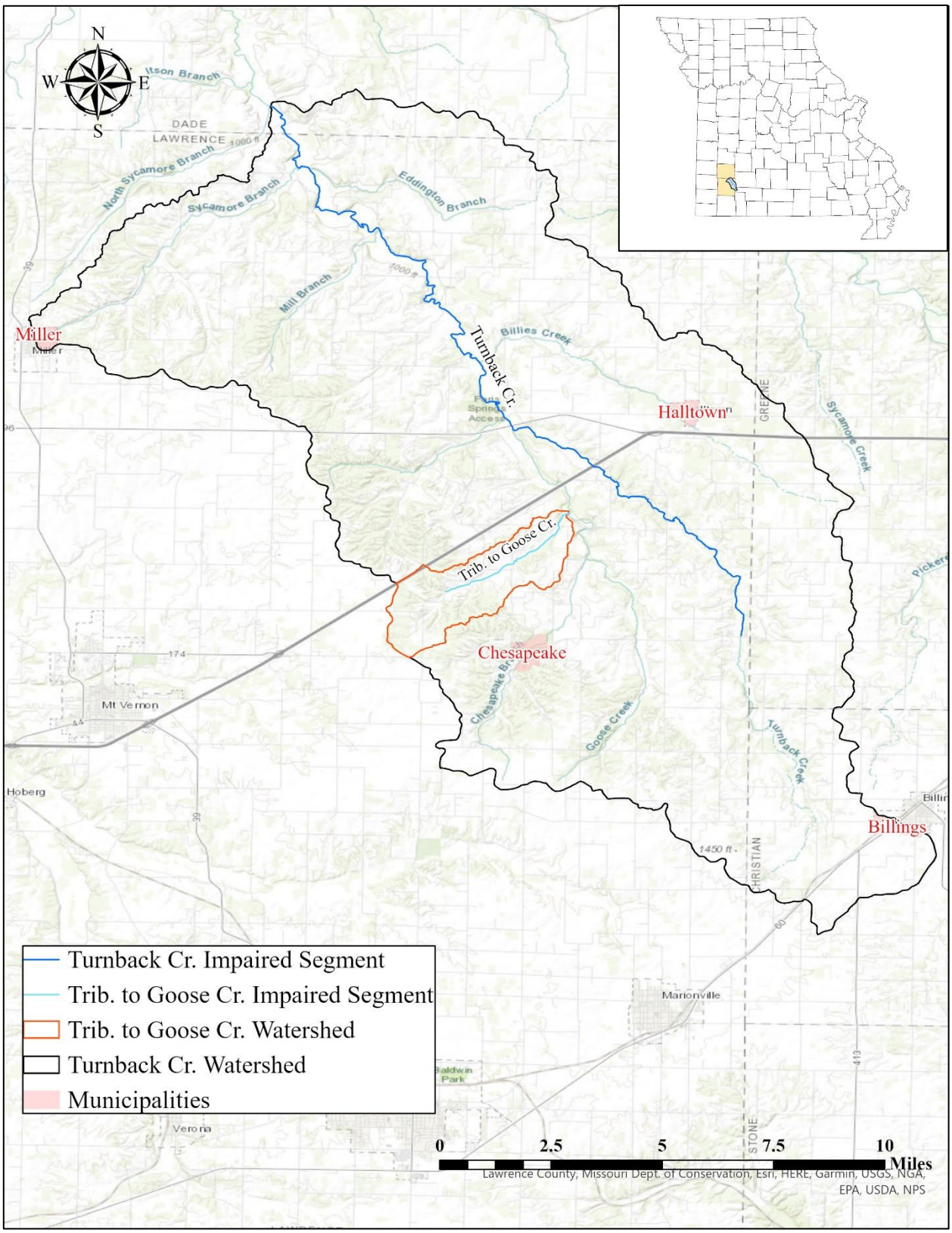

Figure 1. Turnback Creek Watershed with Tributary to Goose Creek Subwatershed

2.1 Geology, Physiography, and Soils

The Turnback Creek watershed is located within the Osage ecological drainage unit, which falls within the Ozark Highlands, covering portions of central and southwestern Missouri (MoRAP 2005). Ecological drainage units are groups of watersheds that have similar biota, geography, and climate characteristics (USGS 2009). Within the Osage ecological drainage unit, Turnback Creek and the Tributary to Goose Creek watersheds are located in the Springfield Plateau EPA Level IV ecoregion (ecological subsection). Ecoregions are areas with similar ecosystems and environmental resources and are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. By recognizing spatial differences in ecosystems, ecoregions stratify the environment by its probable response to disturbance (Chapman et al. 2002). Ecoregions are defined in Missouri's Water Quality Standards at 10 CSR 20-7.031(1)(H).

Like most streams in the Ozark Highlands subregion, streams in the Springfield Plateau Level IV ecoregion occupy narrow valleys separated by steep narrow ridges with clear water, high base flows, and low suspended sediment loads. Streambeds consist mainly of chert gravel and sand. Well-defined riffles, gravel bars, and bluff pools are prevalent. Extensive stretches of bedrock channels are also present. Cliffs and streamside bluffs are common. Steep slopes combined with moderate to slow soil infiltration rates result in frequent flash-flooding during and after intense rainfall events (MoRAP 2005). The Springfield Plateau Level IV ecoregion is underlain by limestone formations. Surface waters are influenced by groundwater from the many springs. There are also numerous losing streams that drain to the subsurface. Geographic Information System (GIS) analysis identified twenty eight springs in the Turnback Creek watershed. There are numerous gaining and losing streams in the headwaters of the Turnback Creek watershed. This includes Tributary to Goose Creek, which is a losing stream.[6]

Soils are categorized into hydrologic soil groups based on similar runoff potentials. Each hydrologic soil group indicates the rate at which water enters the soil profile under conditions of a bare, thoroughly wetted soil surface (NRCS 2009). This infiltration rate determines the quantity of precipitation that flows over land to water bodies as direct runoff. Group A soils have the highest rate of infiltration and the lowest runoff potential. Group D soils have the lowest rate of infiltration and highest runoff potential. Many wet soils fall into dual soil groups (e.g., Group C/D) due to the presence of a seasonal high water table that results in saturation to the soil surface. Dual hydrologic soil groups account for this condition by providing both the drained and undrained condition of the soil.[7] It should be noted that soil runoff potential is only one factor that determines the volume of runoff in a watershed. Impervious surfaces, vegetative cover, slope, rainfall intensity, and land use can significantly influence the potential for runoff regardless of the characteristics of the underlying soil. Figure 2 shows the distribution of hydrologic soil groups and karst features in the Turnback Creek and Tributary to Goose Creek watersheds. Table 1 provides a summary of the hydrologic soil groups by area in square miles and relative percent.

[6] In Missouri, a losing stream is defined in 10 CSR 20.7031(1)(O) as a stream which distributes 30 percent or more of its flow during low flow conditions through natural processes, such as through permeable geologic materials into a bedrock aquifer within two miles flow distance downstream of an existing or proposed discharge.

[7] For the purpose of hydrologic soil group, adequately drained means that the seasonal high water table is kept at least 24 inches (60 centimeters) below the surface in a soil where it would be higher in a natural state (NRCS 2009).

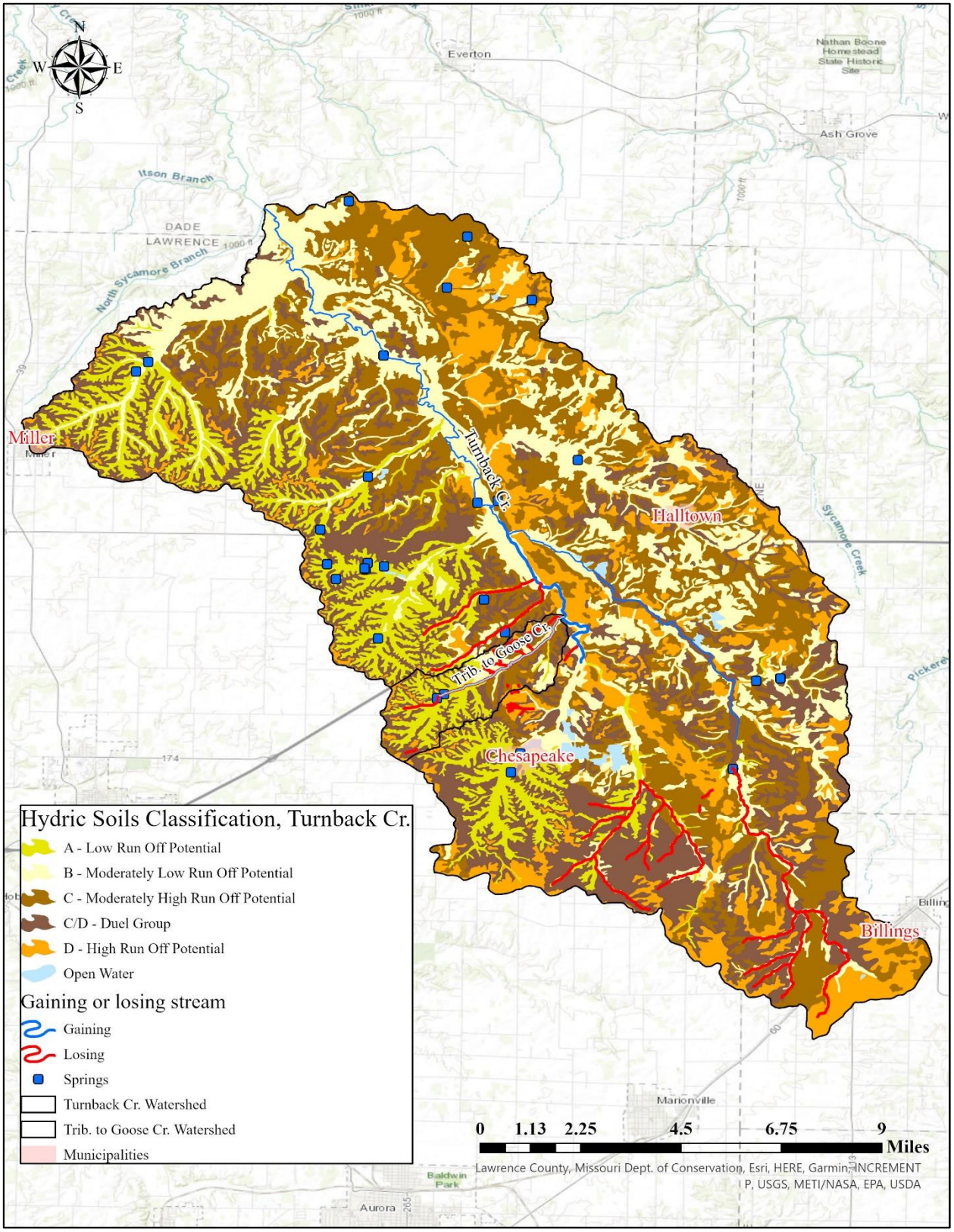

Figure 2. Hydrologic Soil Groups and Karst Features in the Turnback Creek and Tributary to Goose Creek Watersheds

Table 1. Hydrologic Soil Groups in the Turnback and Tributary to Goose Creek Watersheds (NRCS 2020)

Hydrologic Soil Group	Area in the Watershed	
	Square miles	Percent
Turnback Creek*		
Group A	16.25	12.0%
Group B	27.75	20.5%
Group C	37.79	27.9%
Dual Group C/D	33.95	25.1%
Group D	18.91	14.0%
Open Water	0.75	0.55%
Total	135.40	100.0%
Tributary to Goose Creek		
Group A	1.55	32.7%
Group B	0.60	12.7%
Group C	0.78	16.4%
Dual Group C/D	1.52	32.0%
Group D	0.29	6.2%
Total	4.75	100.0%
*Includes Tributary to Goose Creek square mileage.		

2.2 Climate

The most recent climate data from a weather station in close proximity to the Turnback Creek watershed were measured at the National Centers for Environmental Information Mount Vernon Weather Station (USC00235862) in Lawrence County. The climate normals were developed based on temperature and precipitation data collected at that station between 1991 and 2020 (NOAA 2021). Precipitation normals are especially important because they relate to stream flow and runoff events that influence pollutant loading. Table 2 presents the 30-year monthly climate normals from the Mount Vernon Weather Station for precipitation and temperature. Figures 3 and 4 further summarize these data.

Table 2. 30-year Monthly Climate Normals at the Mount Vernon Weather Station

Month	Precipitation Total	Minimum Temperature	Maximum Temperature
	in	ºF	ºF
January	2.38	22.2	44.0
February	2.28	26.0	48.9
March	3.67	35.3	58.0
April	4.55	44.4	67.7
May	5.86	54.3	75.8
June	5.25	63.6	84.3
July	4.01	67.1	89.4
August	3.03	64.9	89.3
September	4.70	56.8	81.5
October	2.95	44.7	70.7
November	3.93	34.5	57.9
December	2.84	26.4	47.2
	Total	**Average**	**Average**
	45.45	45.0	67.9

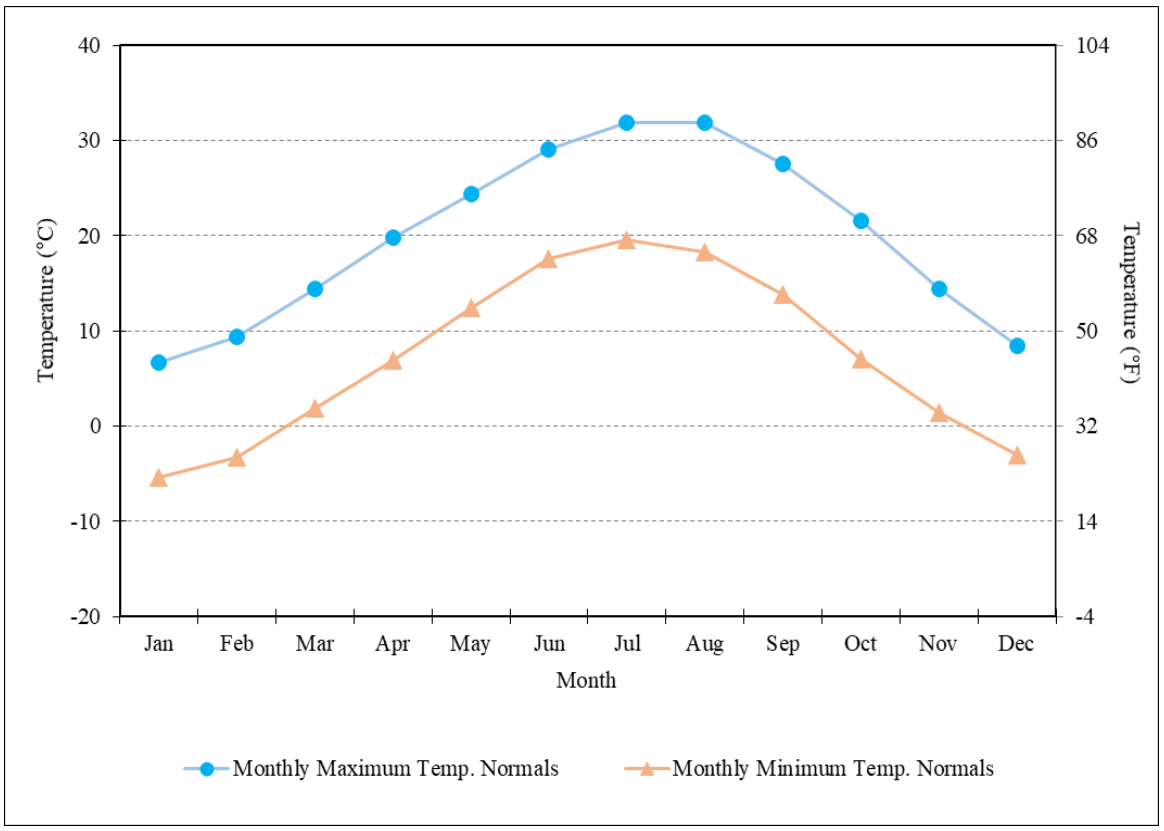

Figure 3. Monthly Minimum and Maximum Temperature Normals – Mount Vernon, MO

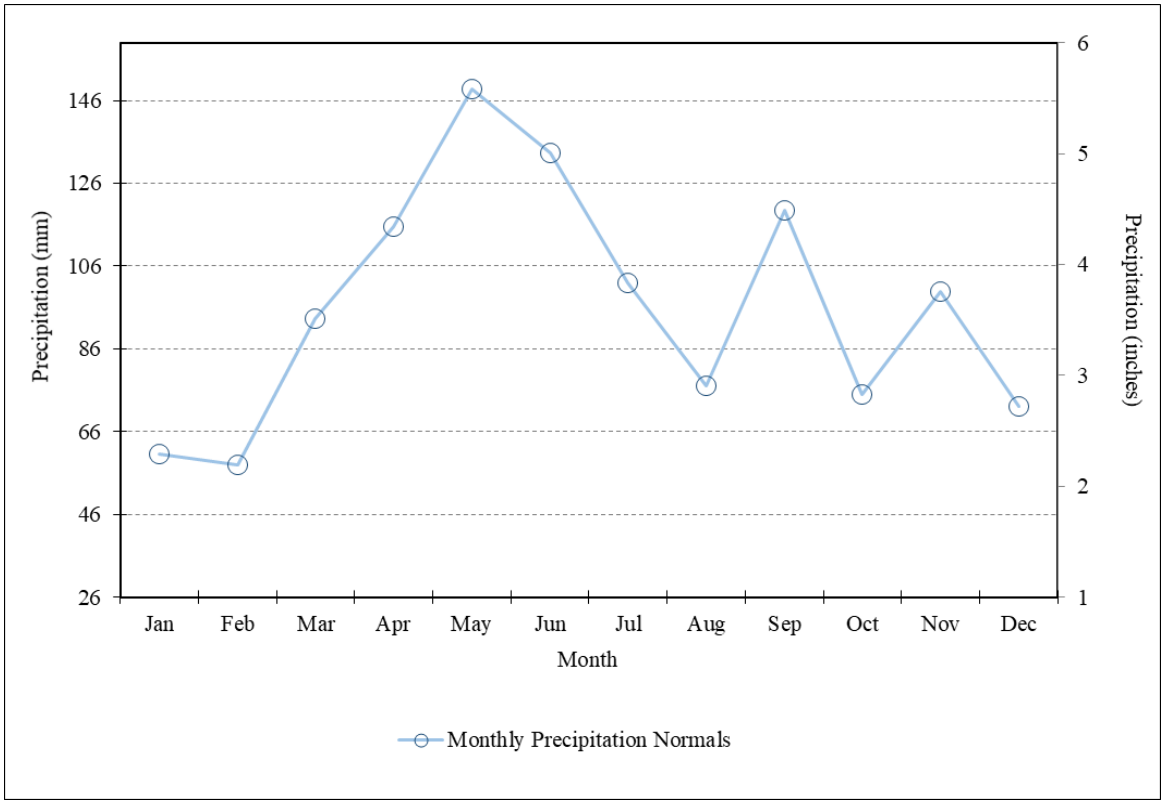

Figure 4. Monthly Precipitation Normals – Mount Vernon, MO

2.3 Population

State and county population estimates are available from the U.S. Census Bureau's 2010 census and can be localized using census block data (U.S. Census Bureau 2010). Population estimates for Turnback Creek and Tributary to Goose Creek watersheds were derived using GIS software by overlaying the watershed boundaries over a map of census blocks (Figure 5). Wherever the centroid of a census block fell within a watershed boundary, the entire population of the census block was included in the total. If the centroid of the census block was outside the boundary, the population of the entire block was excluded. The municipal population was estimated using a similar method whereby municipal areas were overlain on the map of census blocks. The rural population was calculated as the difference between the municipal population and the total population.

As shown in Table 3, the populations in the Turnback Creek watershed and Tributary to Goose Creek have increased since 1990. At the time of the 2010 census, the U.S. Census Bureau did not officially designate urban areas in the watersheds. Urban area designation is one criterion used to determine whether a municipality is subject to municipal separate storm sewer system (MS4) regulations. None of the municipalities in the Turnback Creek watershed or Tributary to Goose Creek watershed are subject to MS4 regulations.

Table 3. Population Estimates for the Turnback Creek Watershed

Municipal			Rural			Total		
1990	**2000**	**2010**	**1990**	**2000**	**2010**	**1990**	**2000**	**2010**
Turnback Creek Watershed								
686	753	748	3,148	3,891	4,569	3,834	4,644	5,317
Tributary to Goose Creek Watershed								
0	0	0	199	226	303	199	226	303

EPA completed a demographic analysis in 2014 to identify areas where environmental justice may be of concern. EPA used demographic information from census block data on a 12-digit HUC scale and a web-based tool called EJSCREEN to determine areas that have potential environmental justice concerns. EPA defines environmental justice as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (USEPA 2014a). Communities determined to have environmental justice concerns may qualify for financial and strategic assistance for addressing environmental and public health issues. The EPA analysis determined there are no 12-Digit HUCs with Environmental Justice Concerns in the Turnback Creek watershed.

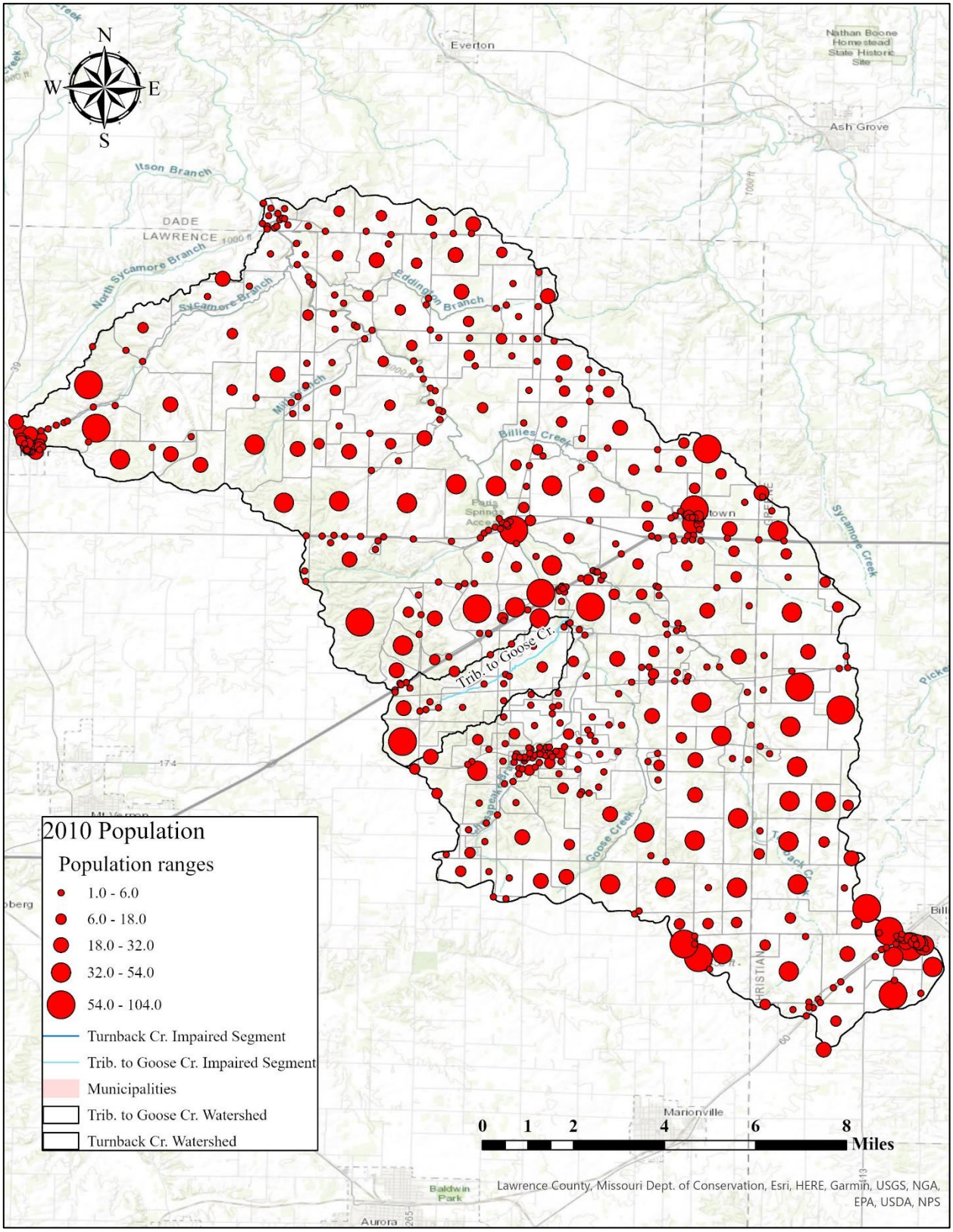

Figure 5. 2010 Population in the Turnback Creek and Tributary to Goose Creek Watersheds

2.4 Land Cover

A land cover analysis was completed using the 2016 National Land Cover Database published by USGS (Dewitz, 2019). Land cover types present in the Turnback Creek and Tributary to Goose Creek watersheds are summarized in Tables 4 and 5. Figure 6 depicts the distribution of the land cover types throughout the watershed. Hay and pasture areas, potentially used for livestock grazing, cover approximately 59 percent of the Turnback Creek watershed and 48 percent of the Tributary to Goose Creek watershed. Interstate 44 bisects the watershed and accounts for developed land cover outside the typical municipal boundaries.

Table 4. Land Cover in the Turnback Creek Watershed

Land Cover Type	Area Square miles	Percent
Developed, High Intensity	0.03	0.03%
Developed, Medium Intensity	0.28	0.21%
Developed, Low Intensity	1.41	1.04%
Developed, Open Space	4.88	3.61%
Barren Land	0.36	0.27%
Cultivated Crops	0.97	0.71%
Hay and Pasture	79.66	58.83%
Shrub and Herbaceous	1.67	1.23%
Forest	45.38	33.51%
Wetlands	0.66	0.49%
Open Water	0.10	0.07%
Totals	135.40	100.00%

Table 5. Land Cover in the Tributary to Goose Creek Watershed

Land Cover Type	Area Square miles	Percent
Developed, High Intensity	0.002	0.03%
Developed, Medium Intensity	0.024	0.50%
Developed, Low Intensity	0.009	0.18%
Developed, Open Space	0.162	3.41%
Hay and Pasture	2.275	47.95%
Shrub and Herbaceous	0.070	1.47%
Forest	2.189	46.14%
Wetlands	0.015	0.31%
Totals	4.744	100.00%

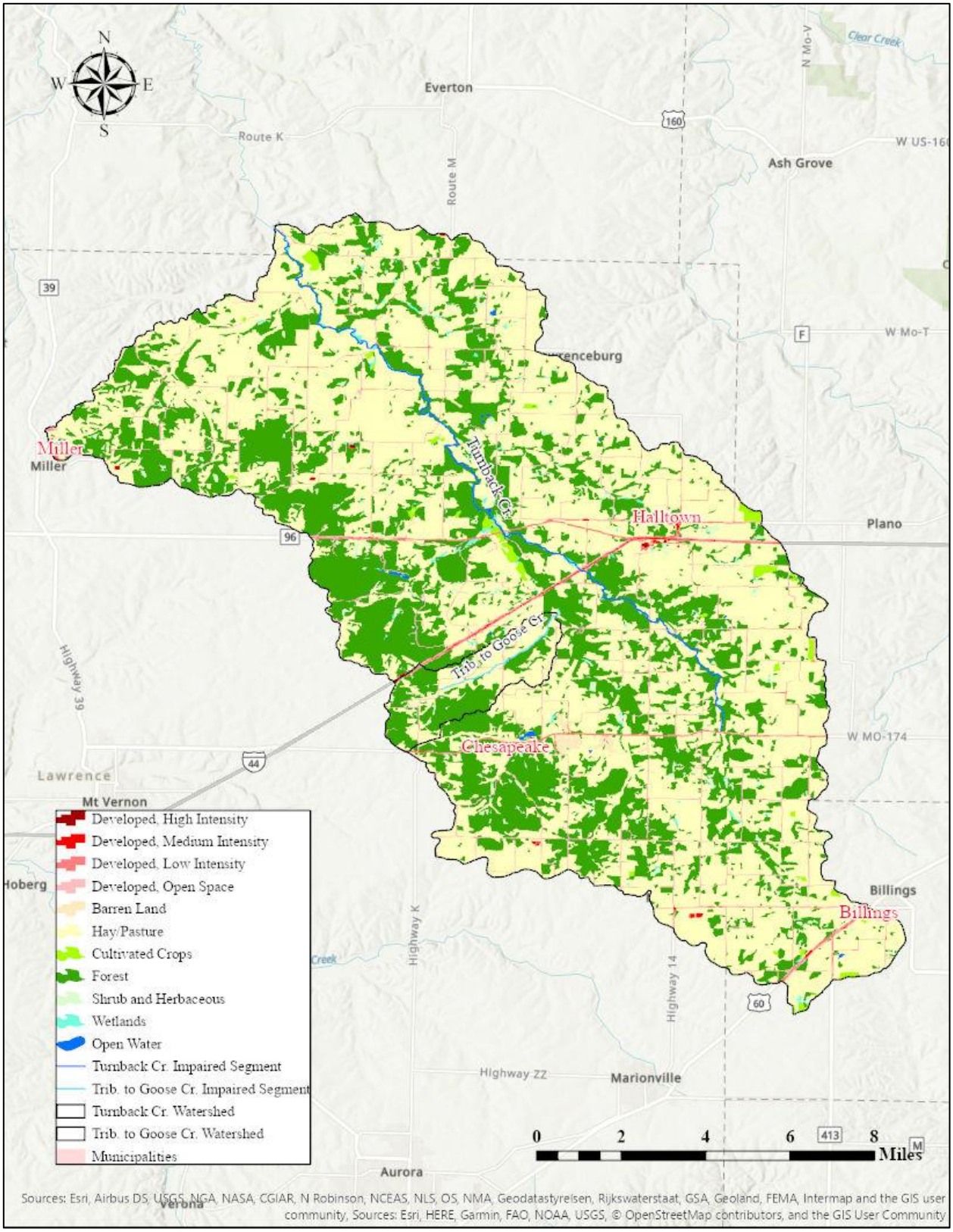

Figure 6. Land Cover in the Turnback Creek and Tributary to Goose Creek Watersheds

3. Applicable Water Quality Standards

TMDLs identify the maximum pollutant load that a water body can assimilate and still attain and maintain water quality standards. Water quality standards are therefore central to the TMDL development process. Under the federal Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters (U.S. Code Title 33, Chapter 26, Subchapter III). Water quality standards consist of three major components: designated uses, water quality criteria, and an antidegradation policy. In accordance with federal regulations at 40 CFR 131.10, Missouri's Water Quality Standards for each individual water body also provide for the attainment and maintenance of water quality in any downstream waters. Revising existing water quality standards is not within the purview of TMDL development. If future water quality monitoring demonstrates that existing water quality standards are not protective of individual water bodies or downstream uses, new water quality standards can be proposed in accordance with the guidance provided in EPA's Water Quality Standards Handbook.[8]

3.1 Designated Uses

Missouri's Water Quality Standards at 10 CSR 20-7.031(1)(C) defines designated uses that are assigned to individual water bodies in accordance with 10 CSR 20-7.031(2) and are listed in 10 CSR 20-7.031, Table G (Lakes) and Table H (Streams). Missouri's Water Quality Standards designate the following uses of Turnback and Tributary to Goose Creeks:

- Irrigation;
- Livestock and wildlife protection;
- Human health protection;
- Protection and propagation of fish, shellfish, and wildlife
    - Warm water habitat (aquatic life);
    - Cold water habitat (Turnback Creek only);
- Recreation in and on the water
    - Whole body contact recreation category A (Turnback Creek);
    - Whole body contact recreation category B (Tributary to Goose Creek); and
    - Secondary contact recreation.

The whole body contact recreation categories A and B designated uses of Turnback Creek and Tributary to Goose Creek are impaired due to high *E. coli* bacteria concentrations. Whole body contact recreation includes activities that involve direct human contact with waters of the state to the point of complete body submergence (10 CFR 20-7.031(1)(C)2.A.). During whole body contact activities, such as swimming, accidental ingestion of the water may occur and there is direct contact to sensitive body organs, such as the eyes, ears, and nose. Whole body contact recreation category A applies to waters that have been established by the property owner as public swimming areas and waters with documented existing whole body contact recreation uses by the public (10 CSR 20-7.031(1)(C)2.A.(I)). Whole body contact recreation category B applies to waters designated for whole body contact recreation not contained within category A (10 CSR 20-7.031(1)(C)2.A.(II)). Secondary contact recreation, which includes activities such as boating, fishing, and wading, are activities that may result in contact with the water that is either incidental or accidental and the probability of ingesting appreciable quantities of water is minimal (10 CSR 20-7.031(1)(C)2.B.). The secondary contact recreation uses are not impaired in Turnback Creek and Tributary to Goose Creek.

[8] https://www.epa.gov/wqs-tech/water-quality-standards-handbook

3.2 Water Quality Criteria

Water quality criteria represent a level of water quality that supports and protects particular designated uses. Water quality criteria are expressed as specific numeric criteria and as general narrative statements. Missouri's Water Quality Standards (10 CSR 20-7.031(4) and (5)) establish general criteria applicable to all waters of the state at all times and specific criteria applicable to waters contained in 10 CSR 20-7.031, Tables G and H. Specific numeric *E. coli* bacteria criteria are given in Missouri's Water Quality Standards at 10 CSR 20-7.031(5)(C) and Table A1. For whole body contact recreation category A waters, *E. coli* concentrations during the recreational season (April through October) shall not exceed the geometric mean of 126 colony forming units (cfu) per 100 milliliters (mL) of water and whole body contact recreation category B waters shall not exceed the geometric mean of 206 cfu/100 mL of water. These criteria are also protective of secondary contact recreational uses.

3.3 Antidegradation Policy

Missouri's Water Quality Standards include the EPA "three-tiered" approach to antidegradation and may be found at 10 CSR 20-7.031(3).

Tier 1 – Protects public health, existing instream water uses, and a level of water quality necessary to maintain and protect existing uses. Tier 1 provides the absolute floor of water quality for all waters of the United States. Existing instream water uses are those uses that were attained on or after November 28, 1975, the date of EPA's first water quality standards regulation related to existing uses.

Tier 2 – Protects and maintains the existing level of water quality where it is better than applicable water quality criteria. Before water quality in Tier 2 waters can be lowered, there must be an antidegradation review consisting of: (1) a finding that it is necessary to accommodate important economic and social development in the area where the waters are located; (2) full satisfaction of all intergovernmental coordination and public participation provisions; and (3) assurance that the highest statutory and regulatory requirements for point sources and best management practices for nonpoint sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the "fishable/swimmable" uses and other existing uses.

Tier 3 – Protects the quality of outstanding national and state resource waters, such as waters of national and state parks, wildlife refuges, and waters of exceptional recreational or ecological significance. There may be no new or increased discharges to these waters and no new or increased discharges to tributaries of these waters that would result in lower water quality.

Waters in which a pollutant is at, near, or exceeds the water quality criteria are considered in Tier 1 status for that pollutant. Therefore, the antidegradation goals for Turnback and Tributary to Goose Creeks are to restore water quality to levels that meet water quality standards.

4. Defining the Problem

E. coli are bacteria found in the intestines of humans and warm-blooded animals and are used as indicators of potential fecal contamination and risk of pathogen-induced illness to humans. In

accordance with Missouri's 2020 Listing Methodology Document, the whole body contact recreation category A designated use for Turnback Creek and category B designated for Tributary to Goose Creek use are impaired because the geometric means of *E. coli* samples collected during the recreational season were greater than 126 cfu/100 mL and 206 cfu/100 mL in the most recent three years having available data with five or more samples.[9] Sufficient data consistent with the assessment methodology are available to support these listings as summarized in Table 6 and Figure 7. As shown, *E. coli* concentrations exceeded the geometric mean of 126 cfu/100 mL during the recreational season in Turnback Creek in 2007, 2008, and 2012. The geometric mean of *E. coli* samples collected from the Tributary to Goose Creek exceeded the 206 cfu/100 mL criteria during the 2007 recreational season.

Individual *E. coli* measurements are provided in Appendix A to illustrate the nature of the impairment but were not used in the calculation of TMDL loading capacities or allocations. Individual measurements may be used to estimate pollutant reduction targets, to target implementation activities, and to select appropriate best management practices. Reduction targets for Turnback Creek and Tributary to Goose Creek are presented in a supplemental TMDL implementation strategies document available online at dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

Table 6. Summary of Recreational Season *E. coli* Data for the Impaired Water Bodies[10]

Water Body	Recreational Season	Number of Samples	Minimum (cfu/100 mL)	Maximum (cfu/100 mL)	Geometric Mean (cfu/100 mL)
Turnback Creek WBID 1414	2007	10	44	365	155
	2008	5	101	435	232
	2012	8	59.8	4,840	263
Tributary to Goose Creek WBID 1420	2007	6	114	727	323
	2008	5	48	308	134

[9] Listing Methodology documents are available online at dnr.mo.gov/env/wpp/waterquality/303d/303d.htm

[10] *E. coli* data may be reported in units of most probably number (MPN) or colony forming units (cfu) depending upon the analysis method used. Data reported as cfu is an actual count of bacteria colonies, where as MPN is a statistical approximation. Although differences may exist, they are often used interchangeably. For purposes of this TMDL all *E. coli* data are presented in units of cfu, regardless of the methodology, for simplicity and in order to maintain consistency with Missouri Water Quality Standards.

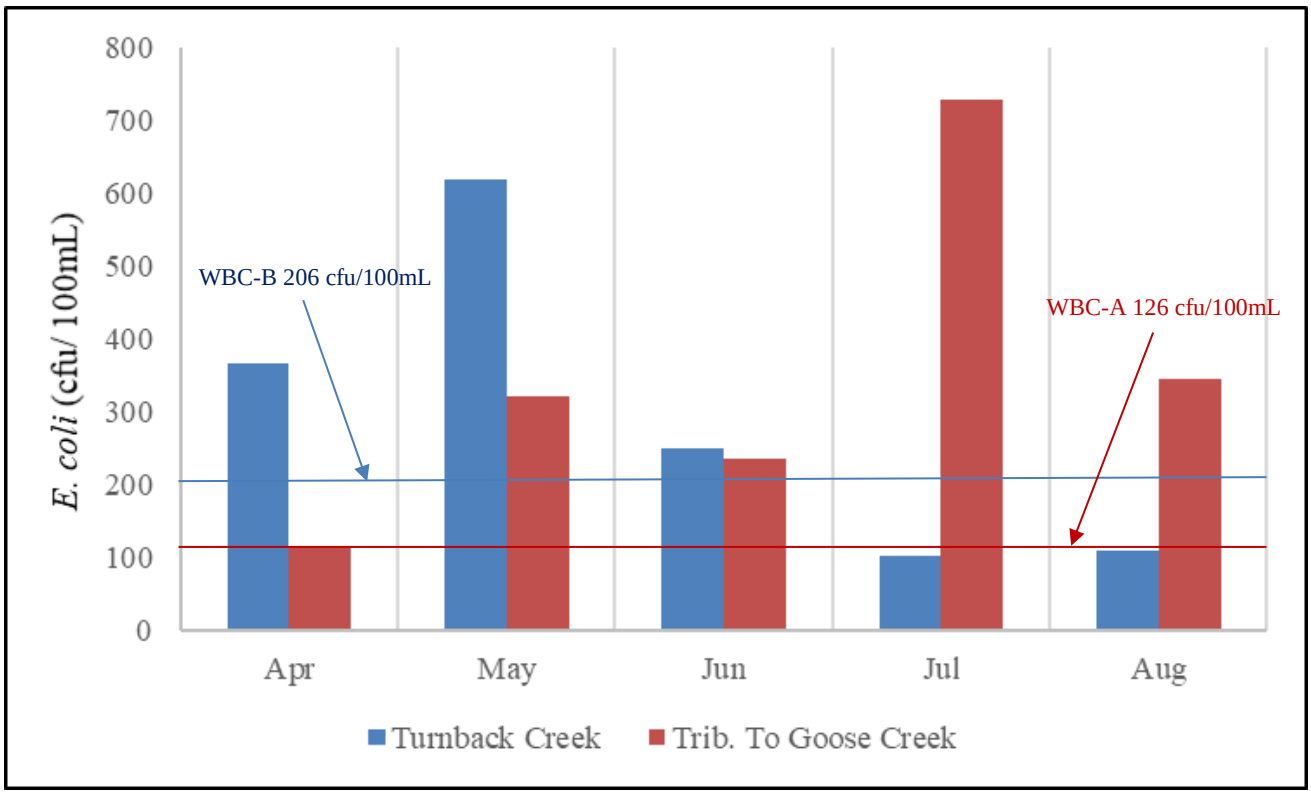

Figure 7. Geometric Means of *E. coli* Data

5. Source Inventory and Assessment

Point (typically regulated) and nonpoint (typically unregulated) sources may contribute to the elevated *E. coli* concentrations in the impaired water bodies. The following source inventory and assessment identifies and characterizes known, suspected, and potential sources of bacteria loading to Turnback and Tributary to Goose Creeks. Sources of bacteria loading are identified and quantified to the extent that information is available.

5.1 Point Sources

Point sources are defined by Section 644.016(16) of the Missouri Clean Water Law and are regulated pursuant to the National Pollutant Discharge Elimination System through the Missouri State Operating Permit program.[11] A point source is defined as "any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. Point source does not include agricultural storm water discharges and return flows from irrigated agriculture." Based on this definition, point sources include domestic wastewater treatment facilities, industrial and commercial facilities, concentrated animal feeding operations (CAFOs), MS4s, and stormwater discharges from industrial areas and construction sites. Illicit straight pipe discharges are also point sources but are illegal and therefore unpermitted. Pollutant loading from point sources is typically most evident during low-flow conditions when stormwater influences are lower or nonexistent. The locations of

[11] The Missouri State Operating Permit program is Missouri's program for administering the federal National Pollutant Discharge Elimination System (NPDES). Generally, the Clean Water Act requires all point sources that discharge pollutants to waters of the United States to obtain an NPDES permit. Issued and proposed operating permits are available online at dnr.mo.gov/env/wpp/permits/index.html.

permitted point sources in the Turnback Creek watershed are presented in Figure 8. Facility types and their expected contributions to the impaired streams are described individually in the following sections.

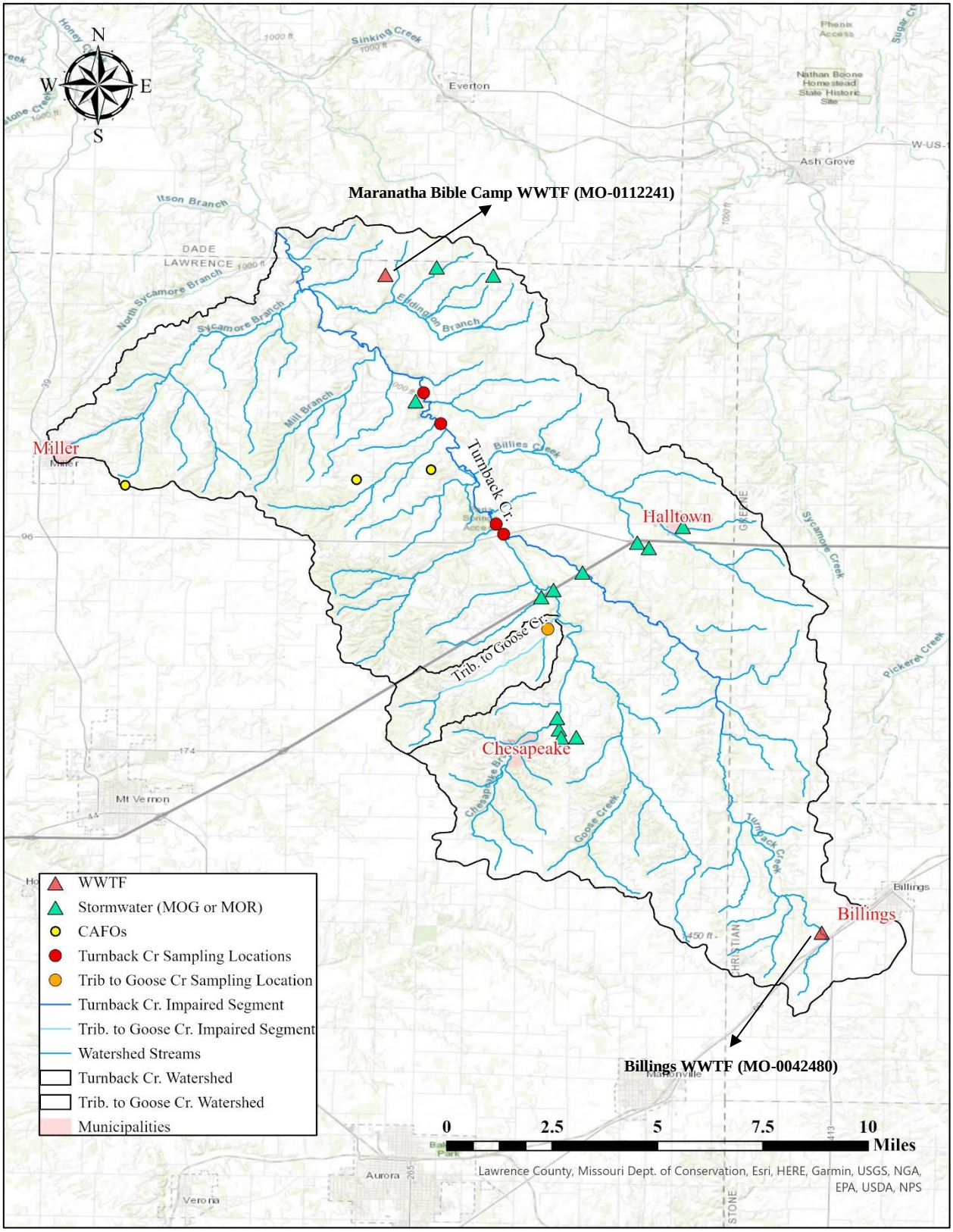

Figure 8. Permitted Features and Outfalls in the Turnback Creek Watershed

5.1.1 Domestic Wastewater Treatment Facilities

Domestic wastewater is primarily household waste, including graywater and sewage. Domestic wastewater treatment facilities include both publicly owned (municipal and sewer districts) and privately owned facilities. Untreated or inadequately treated domestic wastewater discharges can be significant sources of bacteria to receiving waters (USEPA 1986). Facilities equipped with disinfection technologies discharge *E. coli* at very low concentrations and should not cause or contribute to bacteria impairments.

The City of Billings and Maranatha Bible Camp operate domestic wastewater treatment facilities in the Turnback Creek watershed (Table 7). There are no domestic wastewater facilities located within the Tributary to Goose Creek subwatershed. The Billings facility is located in the southern portion of the watershed in Christian County. Located in the northern portion of the Turnback Creek watershed, the Maranatha Bible Camp is the only privately operated domestic wastewater facility in the watershed. Sludge handling for the Billings facility is land applied, while Maranatha Bible Camp facility's sludge is disposed by a contract hauler. Both facilities use chlorination disinfection treatment. When all permit requirements are met, the two municipal wastewater treatment facilities are not exptected to contribute to the water quality impairments of Turnback Creek.

Table 7. Domestic Wastewater Treatment Facilities in the Turnback Creek Watershed

Facility	Permit Number	Design Flow (gpd)	Treatment Type	Permit Expiration
Billings	MO-0042480	121,000	Oxidation ditch, final clarifiers, tertiary sand filter, chlorination/dechlorination	9/30/2023
Maranatha Bible Camp	MO-0112241	10,000	Three-cell lagoon, chlorination/dechlorination,	3/31/2024

Potential bacteria loading from domestic wastewater treatment facilities may also occur from sanitary sewer overflows. Sanitary sewer systems convey residential wastewater, and in some cases commercial and industrial wastewater, to the domestic wastewater treatment facility. Sanitary sewer systems can handle limited amounts of inflow from stormwater and infiltration from groundwater but are typically not designed to collect large amounts of runoff from precipitation events. Overflows from sanitary sewer systems may result in elevated bacteria counts in nearby surface waters (USEPA 1996). Sanitary sewer overflows can be caused by high volume precipitation events and can also occur during dry weather due to blockages, line breaks, sewer defects, power failures, and vandalism. Sanitary sewer overflows can occur at any point in the collection system but are typically evident by overflowing manholes and backups into private residences. Such overflows may discharge directly to nearby waterways or may be restricted to terrestrial locations. These discharges are not authorized by the federal Clean Water Act or the Missouri Clean Water Law.

The Billings wastewater treatment facility reported 61 sanitary sewer overflows or facility bypass events from February 2016 through February 2021. These overflows were primarily precipitation driven events, and generally less than 50,000 gallons in volume, with one event reported occurring due to a power outage. Of the reported events, six reached a tributary to Turnback Creek, three of which only occurred during the recreational season. Corrective actions were taken to address all bypass and sanitary sewer overflow events which occurred at the Billings wastewater treatment facility. Maranatha Bible Camp wastewater treatment facility reported no sanitary sewer overflow or facility bypass events during the same period. Sanitary sewer overflows are not expected to be a significant contributor of *E. coli* to the impaired water bodies because unintentional discharge of

untreated domestic wastewater is rare, and temporary in nature. National Pollutant Discharge Elimination System (NPDES) permits and 40 CFR Part 122.41(e) require permittees to properly operate and maintain their collection systems. This is implemented through a special permit condition or schedule of compliance.

5.1.2 Industrial and Commercial Facilities

Industrial and commercial facilities discharge process water used or generated during mining, manufacturing, or food processing activities, and may also include landfills. Mining and manufacturing facilities are not expected to cause or contribute to bacteria impairments. Food processing wastewater may contain bacteria. There are currently no site-specific permitted industrial or commercial facilities in the Turnback Creek watershed or Tributary to Goose Creek watershed. Industrial or commercial facilities operating in accordance with a general permit are discussed in Section 5.1.5.

5.1.3 Concentrated Animal Feeding Operations

Animal waste generated from CAFOs that is used as fertilizer can be a source of bacteria to water bodies (Rogers and Haines 2005). Pursuant to 10 CSR 20-6.300, permits are required for CAFOs that confine and feed or maintain more than 1,000 animal units for 45 days or more during any 12-month period.[12] Permits may be required for facilities with fewer animal units if pollutants are discharged directly into waters of the state or other water quality issues are discovered. In Missouri, CAFOs operate under site-specific permits or one of two general permits (MO-G01 or MO-GS1).[13]

Three Class IC broiler chicken CAFO facilities are present in the Turnback Creek watershed.[14] There are no CAFO facilities in the Tributary to Goose Creek watershed. Table 8 lists the CAFO facilities in the Turnback Creek watershed. All CAFO facilities in these watersheds operate under the MO-GS1 general permit. Under the MO-GS1 permit, CAFO facilities are not allowed to discharge for any reason, without exception, and any discharge is a violation. Animal waste applied on areas under the control of a CAFO are subject to conditions found in the permit, which include a requirement for the CAFO to develop a nutrient management plan. Section 640.760 Revised Statutes of Missouri (RSMo) establishes setback distances for surface application of liquefied manure from a CAFO by a third party.[15] Although potential sources of *E. coli*, CAFO permits prohibit direct discharge or runoff from land application into water bodies. Therefore when all permit requirements are met, CAFOs should not be significant contributors of bacteria loading to Turnback Creek.

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[12] As defined by CSR 20-6.300(1)(B)2, an animal unit is a unit of measurement to compare various animal types at an animal feeding operation. One (1) animal unit equals the following: 1.0 beef cow or feeder, cow/calf pair, veal calf, or dairy heifer; 0.5 horse; 0.7 mature dairy cow; 2.5 swine weighing over 55 pounds; 10 swine weighing less than 55 pounds; 10 sheep, lamb, or meat and dairy goats; 30 chicken laying hens or broilers with a wet handling system; 82 chicken laying hens without a wet handling system; 55 turkeys in grow-out phase; 125 chicken broilers, chicken pullets, or turkey poults in brood phase without a wet handling system.

[13] The MO-GS1 does not authorize any direct discharges. The MO-G01 allows discharge only in the event of weather that exceeds the criteria of a catastrophic storm, and only authorizes discharge of the portion of stormwater flow that exceeds the design storm event, which includes the direct precipitation and runoff from the 25-year, 24-hour storm event.

[14] An operation's "class size" is a category that is based upon the total number of animal units confined at an operation. The Class IC, IB, and IA are categories that start at 1,000, 3,000, and 7,000 animal units respectively, all of which are required by state regulation to obtain a permit. (1,000 animal units is equal to 2,500 swine; 100,000 broilers; 700 dairy cows; or 1,000 beef steers).

[15] Section 640.760 RSMo requires all third party applicators of liquefied manure from CAFOs to maintain the following minimum setback distances: 50 feet from a property boundary, 300 feet from any public drinking water lake, 300 feet from any public drinking water well or intake structure, 100 feet from any perennial and intermittent streams without vegetation abutting such streams, and 35 feet from any perennial and intermittent streams with vegetation abutting such streams.

Table 8. CAFOs in the Turnback Creek Watershed

Watershed	Permit No.	Facility Name
Turnback Creek	MO-GS10239	NK Farm
	MO-GS10421	Skyline Poultry
	MO-GS10249	Double L Poultry

5.1.4 Municipal Separate Storm Sewer Systems

Municipal separate storm sewer systems (MS4s) are stormwater conveyance systems owned by a public entity that are not part of a sanitary sewer system, a combined sewer system, or part of a domestic wastewater treatment facility. Federal regulations issued in 1990 require that discharges from MS4s be regulated by permits if the population of a municipality, or in some cases a county, is 100,000 or more. As of 1999, federal regulations require permits for discharges from small MS4s that are located within a U.S. Census Bureau defined urban area or are required to hold a MS4 permit based on other criteria by the permitting authority. As discussed in Section 2.3, at the time of the 2010 census, the U.S. Census Bureau did not designate any areas in the watersheds as urban areas. No MS4 permitted entities are located in the Turnback Creek or Tributary to Goose Creek watersheds. Unregulated runoff from developed areas is discussed in Section 5.2.2.

5.1.5 Other General Permitted Wastewater and Stormwater Discharges

General permits are issued for certain wastewater (MO-G) and stormwater (MO-R) discharges based on the type of activity and are intended to be flexible enough to allow for ease and speed of issuance, but must also protect water quality. General wastewater and stormwater permits are issued for activities similar enough to be covered by a single set of requirements. Table 9 lists the effective general and stormwater discharge permits in the Turnback Creek watershed as of June 2021. None of the facilities in Table 9 discharge within the Tributary to Goose Creek watershed. Permits associated with construction or land disturbance activities (MO-RA) are temporary. The number of permits of this type may vary in any given year.

Existing and future activities for which general wastewater or stormwater permits are issued are expected to be conducted in compliance with all permit conditions including monitoring requirements and discharge limitations. Permit conditions are intended to protect the designated uses of all water bodies within the watershed. Activities conducted in accordance with general wastewater and stormwater permit requirements are not expected to contribute *E. coli* loads in amounts substantial enough to cause or contribute to surface water impairments. Per 10 CSR 20-6.010(13)(C), if at any time the Department determines that a general permit is not providing adequate water quality protection, the Department may require the owner or operator of a permitted site or activity to obtain a site-specific operating permit.

Table 9. General (MO-G) and Stormwater (MO-R) Permits in the Turnback Creek Watershed

Watershed	Permit No.	Facility Name	Permit Type	Expires
Turnback Creek	MO-RA13663	Dollar General #20895 - Ash Grove	Construction or Land Disturbance	2/07/2022
	MO-RA13681	Johnson Farms		
	MO-RA13749	Diamond K Lumber LLC		
	MO-RA13817	I-44 Project Bridge Rebuild - ESS		
	MO-R60A431	Meadows Auto Inc.	Motor Vehicle Salvage	12/11/2023
	MO-R130146	J and A Recycling	Textile and Apparel/Printing	9/06/2023
	MO-G490006	Bailey Quarries-Chesapeake Quarry	Limestone Quarries	4/30/2022
	MO-G490084	Bailey Quarries Inc. Fall Valley		4/30/2022
	MO-G490006	Bailey Quarries-Chesapeake Quarry		4/30/2022

5.1.6 Illicit Straight Pipe Discharges

Illicit straight pipe discharges of domestic wastewater are also potential sources of bacteria. These types of sewage discharges bypass treatment systems, such as septic tanks or sanitary sewers, and discharge directly to a stream or an adjacent land area (Brown and Pitt 2004). Illicit straight pipe discharges are illegal and are not authorized by the federal Clean Water Act or the Missouri Clean Water Law. At present, there are no data about the presence or number of illicit straight pipe discharges in the Turnback watershed. For this reason, it is unknown to what significance straight pipe discharges contribute bacteria loads to surface waters in the watershed. Due to the illegal nature of these discharges, any identified illicit straight pipe discharges must be eliminated.

5.2 Nonpoint Sources

Nonpoint sources are diffuse sources with no discernible, confined, or discrete conveyance, and include all categories of discharge that do not meet the definition of a point source. Nonpoint sources are not regulated by the federal Clean Water Act and are exempt from Department permit requirements by state regulation 10 CSR 20-6.010(1)(B)1. Nonpoint source pollutants are typically transported by stormwater runoff, which is minor or negligible during dry weather conditions. Nonpoint sources include agricultural lands, onsite wastewater treatment (septic) systems, and developed areas that do not have regulated storm sewer systems. Nonpoint source pollution can also result from natural background contributions, such as wildlife waste. Streams with little to no riparian buffer are most susceptible to nonpoint source pollution

5.2.1 Agricultural Lands

Croplands, pasturelands, and low-density animal feeding operations are potential sources of bacteria in surface waters. Bacteria are transported in runoff from areas fertilized with animal manure and where livestock are present. Runoff can result from precipitation or excessive irrigation. Soil and Water Conservation Districts provide funding and guidance for the development of nutrient management plans for unregulated private lands. Areas where nutrient management plans guide manure application and where best management practices are used to reduce soil erosion contribute less bacteria to surface waters than unmanaged areas. Although grazing areas are typically well vegetated, livestock tend to congregate near feeding and watering areas, which can create barren areas that are susceptible to erosion (Sutton 1990). Additionally, livestock that are not excluded from streams will deposit manure, and thus bacteria, directly into the waterway.

As noted in Section 2.4 of this document, approximately 59 percent of the land in the Turnback Creek watershed, and approximately 48 percent of the Tributary to Goose Creek subwatershed, are hay and pasture land cover. Aside from livestock present in permitted CAFOs, the exact type and number of livestock present in the watersheds are unknown. The number of cattle in a watershed can be estimated from county cattle population numbers provided in the U.S. Department of Agriculture's 2017 Census of Agriculture (NASS 2017). Based on the 2017 agricultural census there are an average of 148 cows per square mile of hay and pasture in Christian, Dade, Greene and Lawrence counties.[16] This indicates that there are 20,067 cattle in the Turnback Creek watershed. The U.S. Department of Agriculture estimates that a 1,000-pound beef cow produces approximately 59.1 pounds (26.8 kilograms) of manure per day (USDA 1995). Another study found that 1 gram of fresh manure from a cow on pasture contains a population of approximately 758,577 *E. coli* (Weaver et al. 2005). This means that each 1,000-pound cow has the potential to produce 20,329,863,600 *E. coli* per day. A single *E. coli* cell can grow into a colony containing 10^8 cells every 12 hours (Lodish et al. 2000).

Other types of livestock such as horses and sheep may also be contributing bacteria loads in the Turnback Creek and Tributary to Goose Creek watersheds. The number and distribution of other animals in the watershed cannot be estimated from available data. Strategies to reduce *E. coli* loading from agricultural areas are outlined in the supplemental Implementation Strategies document located at dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

5.2.2 Runoff from Developed Areas

As discussed in Section 5.1.4, there are no regulated MS4s in the Turnback Creek watershed. Stormwater runoff from municipal areas may carry high levels of bacteria exceeding water quality criteria during and immediately after storm events (USEPA 1983). *E. coli* contaminated runoff can come from heavily paved areas and areas where soil erosion is common. Common sources of *E. coli* contamination in urban stormwater have been documented as originating from birds, dogs, cats, and rodents (Burton and Pitt 2002). Irrigation runoff from residential lawns where pet wastes are present may also contribute *E. coli* loads to surface waters.

As presented in Section 2.4, developed areas cover small portions of the total Turnback Creek and Tributary to Goose Creek watersheds. Areas categorized as low to high intensity development comprise approximately 1.4 percent of each watershed and areas described as developed open space comprise approximately 4 percent of each watershed. Degradation of water quality associated with imperviousness has been shown to first occur in a watershed at about 10 percent total imperviousness and to increase in severity as imperviousness increases (Arnold and Gibbons 1996; Schueler 1994). Due to the small amount of development in the watershed, runoff from these areas is not expected to contribute substantial amounts of *E. coli* to the impaired water bodies. If the developed areas are expanded in the future, best management practices and low impact development should be considered to mitigate pollutant loading from impervious surfaces.

[16] This analysis assumes all areas identified as hay and pasture are being used for cattle grazing and that cattle are evenly distributed among those areas. Additionally, although some animals may be confined in some areas, for purposes of this estimation the entire cattle population was assumed to be grazing on pasture areas.

5.2.3 Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems treat and disperse domestic wastewater on the property where it is generated. When properly designed and maintained, these systems perform well and should not contribute substantial amounts of *E. coli* to surface waters. However, when these systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration) there can be adverse effects to surface water quality (Horsley and Witten 1996). The Missouri Department of Health and Senior Services or local administrative authorities (commonly the local health department) have jurisdiction over onsite wastewater treatment systems with a design or actual flow of 3,000 gallons per day or less. Municipalities or counties may impose more stringent or additional requirements for owners of septic systems. The Missouri Department of Health and Senior Services estimates that approximately 25 percent of homes in Missouri utilize onsite wastewater treatment systems, particularly in rural areas where public sewer systems are not available (DHSS 2020). Failing onsite wastewater treatment systems can contribute *E. coli* to nearby streams under wet or dry weather conditions directly or through surface runoff and groundwater flows.

The exact number of onsite wastewater treatment systems in the Turnback Creek watershed is unknown. EPA's online input data server for the Spreadsheet Tool for Estimating Pollutant Load (STEPL) provides estimates of septic system numbers by 12-digit HUC watersheds based on 1992 and 1998 data from the National Environmental Service Center (USEPA 2014b).[17] These STEPL derived estimates of septic system numbers are provided in Table 10. Due to modest increases in the rural population of the watersheds since the 1990 census, this data is assumed to provide a reasonable estimate of actual septic system numbers.

Septic systems fail due to age and poor maintenance. Table 10 also provides statewide estimated failure rates from a study by the Electric Power Research Institute (EPRI 2000). The study suggests that in parts of Missouri, up to 50 percent of onsite wastewater treatment systems may be failing. Due to these high failure rates, onsite wastewater treatment systems are potential sources of bacteria loading to surface waters in Missouri. However, aerial imagery indicates that there are few residences in close proximity to Turnback and Tributary to Goose Creeks, so direct *E. coli* loading to the impaired streams from septic systems is likely minimal.

Table 10. STEPL Derived Estimates of Septic System Numbers

12-digit HUC	Watershed Name	No. of Systems	Population per System	% Septic Failure Rate
102901060101	Goose Creek	205	2	30% - 50%
102901060102	Headwaters Turnback Creek	211	2	
102901060103	Billie Creek-Turnback Creek	244	2	
102901060105	Sycamore Branch-Turnback Creek[18]	45	2	
	Total:	705		

5.2.4 Natural Background Contributions

Wildlife such as deer, waterfowl, raccoons, rodents, and other animals contribute to the natural background concentrations of *E. coli* that may be found in a water body. Such contributions may be

[17] The National Environmental Services Center is located at West Virginia University and maintains a clearinghouse for information related to, among other things, onsite wastewater treatment systems. Available URL: www.nesc.wvu.edu/

[18] Only a portion (46 percent) of the impaired segment watershed comprises the Sycamore Branch-Turnback Creek HUC-12, values are area weighted corrected.

a component of runoff from agricultural areas, developed areas, forest lands, and other areas. While typical wildlife populations are not expected to cause or contribute to water body impairments, animals that congregate in large groups on or near water bodies may contribute significant bacteria to surface waters. For instance, Canada geese have been found to contribute significant bacteria loads in some waters (Ishii et al. 2007). There are no watershed-specific population data for Canada geese or other waterfowl, but the Missouri Department of Conservation estimated that the statewide resident Canada goose population was approximately 55,000 birds in 2016 and that the five-year average statewide duck population is 393,858 birds (MDC 2016; MDC 2020). The exact number of deer in the watershed is also not known, but the Missouri Department of Conservation keeps harvest records by county for each hunting season. Harvest data provides a general idea of the amount of deer that may be present in an area. Total 2019 harvests for Dade and Lawrence Counties were 3,595 deer (MDC 2020). Bacteria can also be resuspended from the sediment as bacteria lives longer in the sediment than in water (Davis and Barr 2006; Marino and Gannon, 1991). Resuspension has been found to occur during sediment disturbance and activities such as dredging, boating in shallow area, and swimming. The significance of any resuspended bacteria to the impairment in Turnback Creek and Tributary to Goose Creek is unknown. Natural background contributions are included in the nonpoint source load allocation. Natural background contributions are included in the nonpoint source load allocations.

5.2.5 Riparian Corridor Conditions

Riparian corridor conditions have a strong influence on instream water quality. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in the attenuation of pollutants in runoff. Land cover within 100 feet of streams in the Turnback Creek and Tributary to Goose Creek watershed are presented in Tables 11 and 12. Hay and pasture constitute approximately 47 percent of the riparian corridors in the Turnback Creek watershed and approximately 53 percent of the riparian corridors in the Tributary to Goose Creek watershed. These areas may be more susceptible to *E. coli* loading when livestock grazing is occurring (Line et al. 2000). Approximately 43 percent of the riparian corridors in the Turnback Creek watershed are forested. This indicates that some *E. coli* transported from adjacent cropland and pasture lands into those areas may be intercepted before it enters the streams.

Table 11. Land Cover of Riparian Corridors in the Turnback Creek Watershed[19]

Land Cover Type	Riparian Corridor Land Cover Type Area	
	Acres	Percent
Barren Land	8.16	0.17%
Cultivated Crops	28.47	0.58%
Developed, Low Intensity	29.64	0.61%
Developed, Medium Intensity	2.27	0.05%
Developed, Open Space	123.41	2.53%
Forest	2,104.03	43.17%
Hay/Pasture	2,279.80	46.78%
Open Water	18.46	0.38%

[19] Values include Tributary to Goose Creek riparian corridor critical land use areas.

Shrub and Herbaceous	85.81	1.76%
Wetlands	193.51	3.97%
Total:	4,873.56	100.00%

Table 12. Land Cover of Riparian Corridors in the Tributary to Goose Creek

Land Cover Type	Riparian Corridor Land Cover Type Area	
	Acres	**Percent**
Developed, Open Space	9.29	5.78%
Forest	54.41	33.84%
Hay/Pasture	84.72	52.69%
Shrub and Herbaceous	4.65	2.89%
Wetlands	7.71	4.80%
Total:	160.79	100.00%

6. Calculating Loading Capacity

A TMDL is equal to the loading capacity of a water body for a specific pollutant, which is the maximum pollutant load that a water body can assimilate and still attain and maintain water quality standards. The loading capacity is derived from the numeric water quality criterion for each pollutant or an appropriate surrogate when no numeric criterion is applicable. Once the maximum allowable pollutant load is determined, a portion is assigned to point sources as a wasteload allocation and to nonpoint sources as a load allocation. A margin of safety is required to account for uncertainties in scientific and technical understanding of water quality in natural systems (CWA Section 303(d)(l)(C) and 40 CFR 130.7(c)(l)). The loading capacity is equal to the sum of the wasteload allocation, load allocation, and the margin of safety as follows:

$$TMDL = LC = \sum WLA + \sum LA + MOS$$

where LC is the loading capacity, ∑WLA is the sum of the wasteload allocations, ∑LA is the sum of the load allocations, and MOS is the margin of safety.

7. Total Maximum Daily Loads

According to 40 CFR 130.2(i), TMDLs can be expressed in terms of mass per unit time, toxicity, or other appropriate measures. The TMDLs for Turnback Creek and Tributary to Goose Creek are expressed as *E. coli* cfu per day using load duration curves developed using the *E. coli* criterion concentration of 126 cfu/100 mL, all possible stream flows, and a unit conversion factor.[20] Although this target concentration is associated with the whole body contact A recreational use, it is used in this TMDL to establish loading for Tributary to Goose Creek, which is designated with the whole body contact B use. This conservative approach is protective of downstream water quality, and accounts for any uncertainty associated with estimated flows and true losing stream conditions. Establishing TMDLs using load duration curves is consistent with the Anacostia Ruling (*Friends of*

[20] $\boldsymbol{Load}\left(\frac{\text{count}}{\text{time}}\right) = \boldsymbol{Concentration}\left(\frac{\text{count}}{\text{volume}}\right) * \boldsymbol{Flow}\left(\frac{\text{volume}}{\text{time}}\right) * \boldsymbol{conversion\ factor}$ (24,465,715)

the Earth, Inc., et al v. EPA, No 05-5010, April 25, 2006) and EPA guidance in response to that ruling (USEPA 2006; USEPA 2007a).

The selected TMDL target is protective of whole body and secondary contact recreational uses. The resulting load duration curves provide a visual representation of the pollutant loading capacity of the water bodies at all stream flows. The Turnback Creek and Tributary to Goose Creek TMDLs are applicable during the recreational season when the *E. coli* criteria apply. Using this approach the available loading capacity of the stream varies with flow, but the pollutant concentration remains constant. Although TMDLs are expressed as daily mass loads, *E. coli* criteria associated with the protection of recreational uses are expressed as geometric mean concentrations. Therefore, fluctuations in instantaneous concentrations are expected and individual bacteria measurements greater than the applicable criterion do not necessarily indicate a violation of water quality standards. Additional discussion about the methods used to develop the load duration curves for Turnback Creek and Tributary to Goose Creeks are provided in Appendix B.

Observed data for Turnback Creek and Tributary to Goose Creek are plotted on the load duration curve graphs to illustrate the frequency of exceedance and the magnitude of pollutant load reductions needed to meet the TMDL and attain water quality standards. Points above the curve exceed the loading capacity and points on or below the curve are in compliance with water quality standards. The load duration curves also help to identify and differentiate between storm-driven loading and the presence of continuous loading. Storm-driven loading is expected under wet conditions when precipitation and runoff are high. Continuous loading is evident at low flows when point source discharges have greater influence on water quality. Load reductions needed to meet the *E. coli* criterion can be calculated using the geometric means of observed data within each flow percentile range and are provided in the supplemental Implementation Strategies document located at dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

The *E. coli* load duration curves for Turnback Creek and Tributary to Goose Creek are displayed in Figures 9 and 10. The y-axes quantify the *E. coli* mass load in cfu per day at the flow conditions (percentage of time flow is equaled or exceeded) on the x-axes. Lower flows are equaled or exceeded more frequently than higher flows (i.e., greater than 90 percent of the time). The flow ranges are consistent with EPA guidance for using load duration curves to develop TMDLs (USEPA 2007b).

The TMDLs and associated allocations at selected percentile flow exceedances are displayed in Tables 13 and 14. Due to the extremely large numbers associated with bacteria loads, *E. coli* values are presented using scientific notation. Specific allocations for individual sources are discussed in Sections 8 and 9.

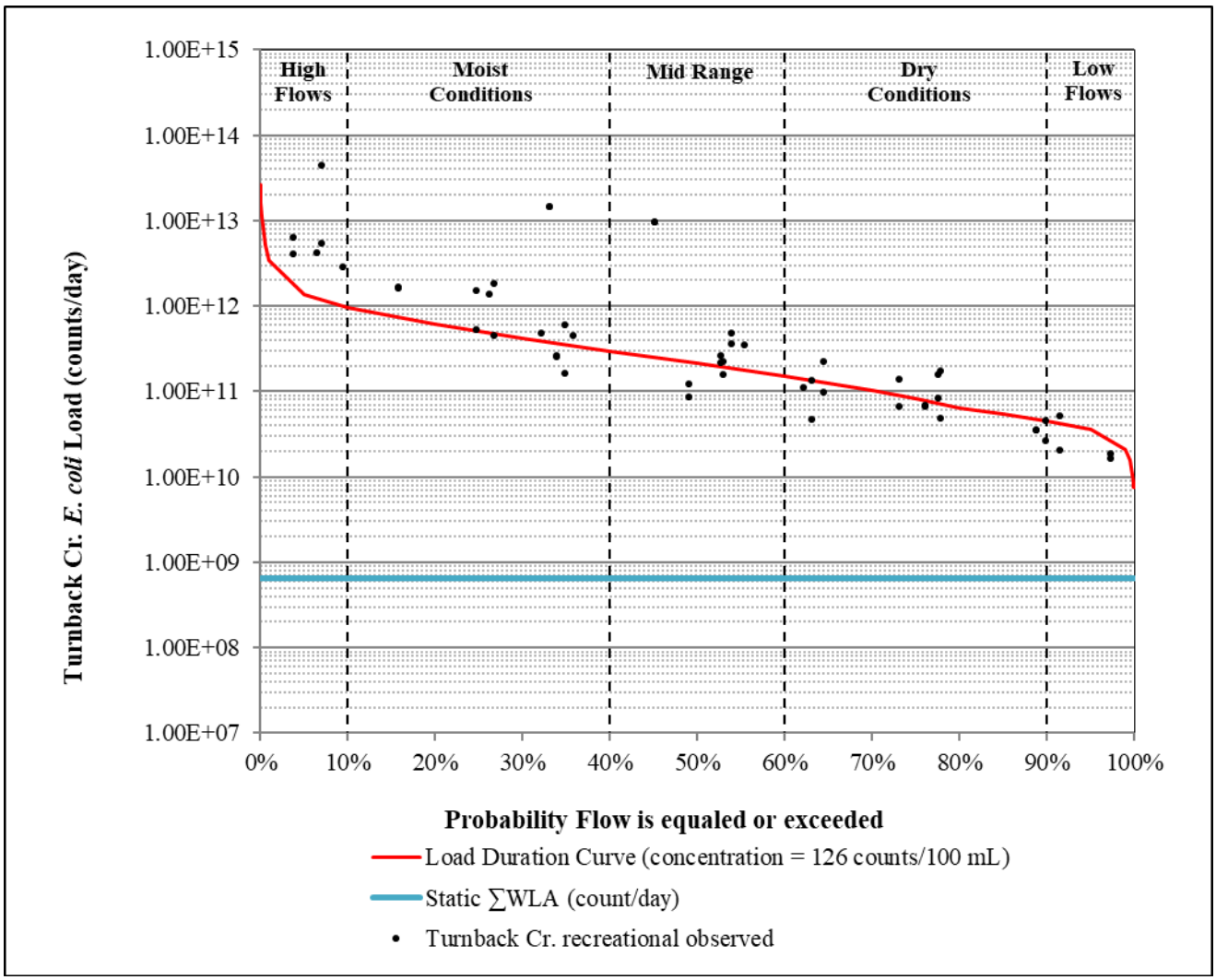

Figure 9. *E. coli* TMDL for Turnback Creek (WBID 1414)

Table 13. *E. coli* TMDL and Allocations for Turnback Creek at Selected Flows

Percent of time flow is equaled or exceeded	Flow ft^3/s	LC (counts/day)	∑WLA (counts/day)	∑LA (counts/day)	MOS (counts/day)
95	11.76	3.63E+10	6.56E+08	3.20E+10	3.63E+09
75	26.46	8.16E+10	6.56E+08	7.28E+10	8.16E+09
50	69.12	2.13E+11	6.56E+08	1.91E+11	2.13E+10
25	162.95	5.02E+11	6.56E+08	4.51E+11	5.02E+10
5	442.80	1.37E+12	6.56E+08	1.23E+12	1.37E+11

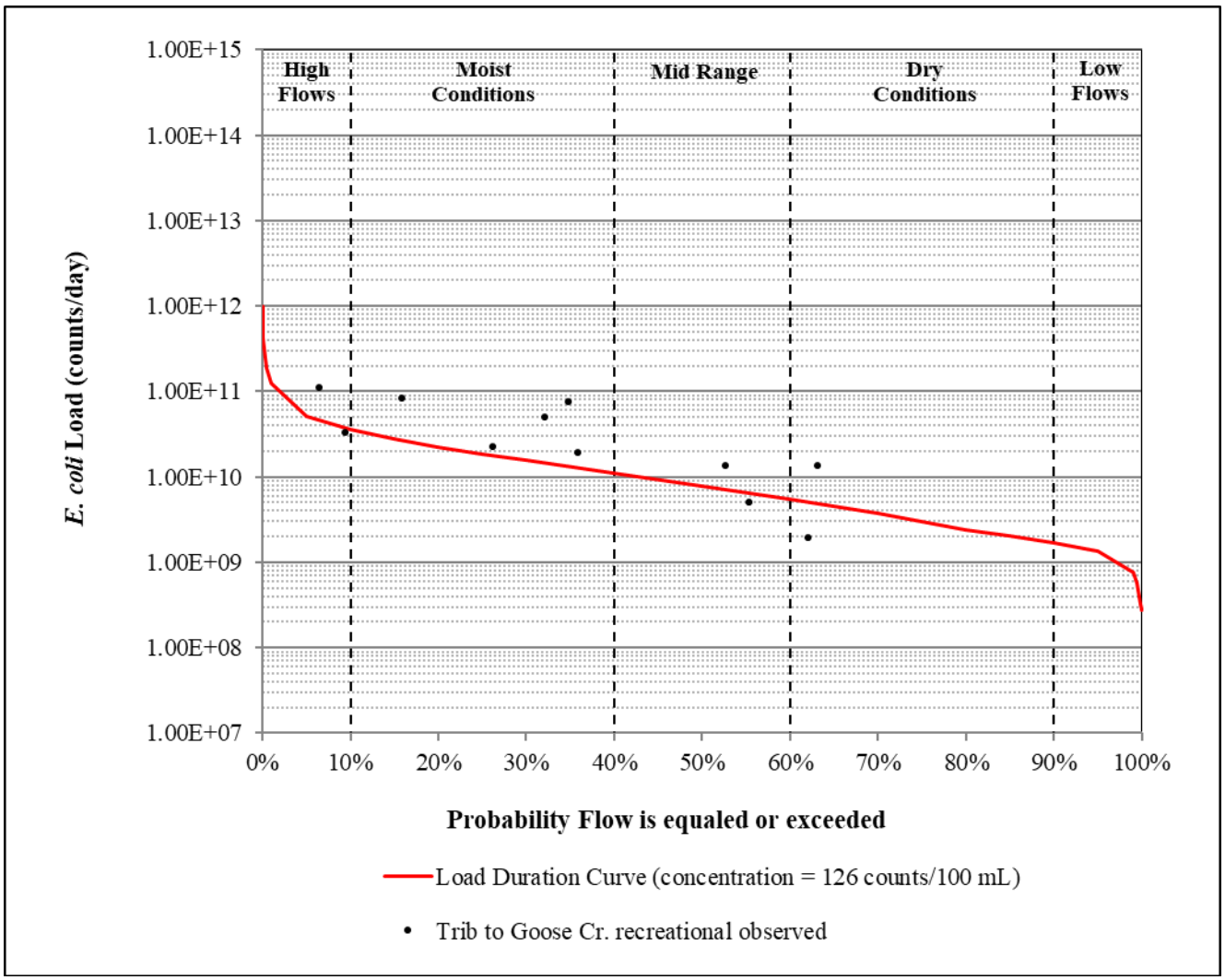

Figure 10. *E. coli* TMDL for tributary to Goose Creek (WBID 1420)

Table 14. *E. coli* TMDL and Allocations for tributary to Goose Creek at Selected Flows*

Percent of time flow is equaled or exceeded	Flow ft^3/s	LC (counts/day)	∑WLA (counts/day)	∑LA (counts/day)
95	0.44	1.34E+09	0	1.34E+09
75	0.98	3.02E+09	0	3.02E+09
50	2.56	7.89E+09	0	7.89E+09
25	6.04	1.86E+10	0	1.86E+10
5	16.40	5.06E+10	0	5.06E+10

* An implicit margin of safety is used

8. Wasteload Allocation (Point Source Load)

The wasteload allocation is the portion of the loading capacity assigned to existing or future point sources. Two permitted point source facilities currently operate in the Turnback Creek watershed and will receive *E. coli* wasteload allocations based on facility design flows. The Tributary to Goose Creek watershed currently contains no point source loading, therefore no wasteload allocations were

allotted. Pursuant to 40 CFR 122.44(d)(1)(vii)(B), effluent limits or other permit conditions must be consistent with the assumptions and requirements of TMDL wasteload allocations.

The wasteload allocations presented in this TMDL report do not preclude the establishment of future point sources. Any future point sources should be evaluated against the TMDL, the range of flows with which any additional bacterial loading will affect, and any additional requirements associated with antidegradation. Federal regulation 40 CFR 122.4(a) disallows the issuance of an NPDES permit if the conditions of the permit cannot provide for compliance with the applicable requirements of the federal Clean Water Act, or regulations promulgated under the federal Clean Water Act. Additionally, 40 CFR 122.4(i) states no permit may be issued to a new source or new discharger if the discharge from its construction or operation will cause or contribute to violation of water quality standards. After undergoing antidegradation review, any new facility that discharges wastewater containing *E. coli* should operate in a manner that will not result in loading greater than the established wasteload allocation. New facilities that disinfect wastewater prior to discharge or implement other appropriate measures to eliminate *E. coli* from effluent during the recreational season (e.g., no discharge or batch discharge) will result in *de minimis* bacteria loading and will not cause or contribute to the impairments. Decommissioning of onsite wastewater treatment systems and connecting to sewerage systems for wastewater treatment will result in net pollutant reductions that are consistent with the goals of this TMDL.

8.1 Domestic Wastewater Treatment Facilities

The aggregated wasteload allocations for domestic wastewater dischargers in the Turnback Creek watershed is 6.56E+08 *E.coli* counts/day. The Tributary to Goose Creek watershed contains no domestic wastewater treatment facilities. These allocations are based on individual facility design flows presented in Table 15 and the *E. coli* criterion concentration applicable to the facility's receiving stream. Both domestic wastewater treatment facilities discharge to streams designated for whole body contact recreation category B, which has an applicable criterion of 206 cfu/100mL. However, the receiving stream for the Billings facility is also a losing stream. Missouri effluent regulations at 10 CSR 20-7.015(9)(B)1.D. require *E. coli* to be limited year-round to 126 cfu/100mL to be expressed as a daily maximum. Actual flows that are less than the design flows may allow these facilities to discharge bacteria loads less that the calculated wasteload allocations. The wasteload allocations in this TMDL report do not authorize any facility to discharge bacteria at concentrations that exceed water quality standards, but may accommodate additional facility loading due to population increases or expansions in service area. The wasteload allocations in this TMDL report are applicable at all flows during the recreational season and do not include loading that may result from sanitary sewer overflows. Sanitary sewer overflows are unpermitted discharges are not authorized under the Clean Water Act. For this reason, sanitary sewer overflows in the Turnback Creek watershed are assigned wasteload allocations of zero at all flows.

Table 15. Wasteload allocations for domestic wastewater discharges

Permit Number	Facility Name	Design Flow (gallon per day)	E. coli concentration (count/100 mL)	WLA (count/day)
MO-0042480	Billings WWTF	121,000	126	5.78E+08
MO-0112241	Maranatha Bible Camp WWTF	10,000	206	7.81E+07

8.2 Industrial and Commercial Facilities
There are currently no site-specific permitted industrial or commercial facilities in the Turnback and Tributary to Goose Creek watersheds.

8.3 Concentrated Animal Feeding Operations
All CAFO facilities in the Turnback Creek watershed are subject to permits that do not allow discharge. For this reason, the *E. coli* wasteload allocations for all CAFO facilities are zero at all flows. Additionally, CAFO facilities must follow permit conditions associated with land application and should not be a contributor of *E. coli* loads at concentrations that cause or contribute to water body impairments.

8.4 Municipal Separate Storm Sewer Systems
There are no regulated MS4s in the Turnback Creek and Tributary to Goose Creek watersheds. *E. coli* in stormwater runoff from developed areas are included in the load allocation for nonpoint sources. If MS4 permits are required for stormwater discharges from urban areas in the future, then the appropriate proportion of the load allocation, as it relates to stormwater pollutant contributions, may be re-assigned as a wasteload allocation.

8.5 Other General Permitted Wastewater and Stormwater Discharges
Activities that require general or stormwater permits are not typically expected to contribute *E. coli* to surface waters, and permit conditions are protective of the designated uses assigned to all water bodies in the watersheds. Activities for which these permits are issued are expected to be conducted in compliance with all permit conditions, including any land application, monitoring, stormwater pollution prevention plans, and discharge limitations. For these reasons, the *E. coli* wasteload allocations for these facilities are set at existing permit limits and conditions. Future general and stormwater permitted activities that do not actively generate bacteria and that operate in full compliance with permit conditions are not expected to contribute bacteria loads above *de minimis* levels and will not result in loading that exceeds the sum of the TMDL wasteload allocations.

8.6 Illicit Straight Pipe Discharges
Illicit straight pipe discharges are illegal and are not permitted under the federal Clean Water Act. For this reason, illicit straight pipe discharges are assigned an *E. coli* wasteload allocations of zero. Any existing illicit straight pipe discharges must be eliminated and future discharges of this type should be prevented.

9. Load Allocation (Nonpoint Source Load)
The load allocation is the portion of the loading capacity assigned to existing and future nonpoint sources and natural background contributions (40 CFR 130.2(g)). The load allocation for this TMDL is calculated as the remainder of the loading capacity after allocations to the wasteload allocation and the margin of safety, as presented in Section 7. The load allocations include contributions from agricultural lands, runoff from developed areas, and natural background contributions. No portion of the load allocation is assigned to onsite wastewater treatment systems because when they are properly maintained and operating as designed they do not discharge *E. coli* directly to surface waters.

10. Margin of Safety

A margin of safety is required to account for uncertainties in scientific and technical understanding of water quality in natural systems (CWA Section 303(d)(l)(C) and 40 CFR 130.7(c)(l)). Based on EPA guidance, the margin of safety can be achieved through two approaches:

- Explicit - Reserve a portion of the loading capacity as a separate term in the TMDL.
- Implicit - Incorporate the margin of safety within the wasteload allocation and the load allocation calculations by making conservative assumptions in the analysis.

An explicit margin of safety equal to 10 percent of the loading capacity is included in the TMDL for Turnback Creek. For Tributary to Goose Creek, the loading capacity is calculated using the criterion concentration associated with the whole body contact recreation category A recreational use. This is a more stringent target and serves as an implicit margin of safety. Additionally, for both streams bacteria decay rates were not applied and the direct recreational-season geometric mean was used for estimating the daily loading value as required by the federal Clean Water Act. These conservative assumptions serve as additional implicit margins of safety.

11. Seasonal Variation

Federal regulations at 40 CFR 130.7(c)(1) require that TMDLs take into consideration seasonal variation in applicable water quality standards. The load duration curves provide the *E. coli* loading capacities for each water body at all possible flow regimes using data collected during all seasons. The *E. coli* TMDLs are therefore protective of designated uses during critical conditions throughout the recreational season for Turnback Creek and Tributary to Goose Creek, including during high flows associated with intense rainfall events when bacteria loading is more likely.

12. Monitoring Plans

The Department conducts water quality monitoring in impaired waters within a reasonable timeframe following the approval of TMDLs, completion of facility upgrades and permit compliance schedules, or the implementation of watershed BMPs. The Department will also routinely examine any available quality-assured water quality data collected by other local, state, and federal entities in order to assess the effectiveness of TMDL implementation. In addition, certain quality-assured data collected by universities, municipalities, private companies, and volunteer groups may be used to assess water quality following TMDL implementation.

13. Reasonable Assurance

Section 303(d)(1)(C) of the federal Clean Water Act requires that TMDLs be established at a level necessary to implement applicable water quality standards. As part of the TMDL process, consideration must be given to the assurances that point and nonpoint source allocations will be achieved and water quality standards attained. Where TMDLs are developed for waters impaired by point sources only, reasonable assurance is provided through the NPDES permitting program. State operating permits requiring effluent and instream monitoring be reported to the Department provide reasonable assurance that instream water quality standards will be met.

Where a TMDL is developed for waters impaired by both point and nonpoint sources, point source wasteload allocations must be stringent enough so that in conjunction with the water body's other loadings (i.e., nonpoint sources) water quality standards are met. Reasonable assurance that nonpoint sources will meet their allocated amount is dependent upon the availability and

implementation of nonpoint source pollutant reduction plans, controls, or best management practices within the watershed. If best management practices or other nonpoint source pollution controls allow for more stringent load allocations, then wasteload allocations can be less stringent. Thus, the TMDL process provides for nonpoint source control tradeoffs (40 CFR 130.2(i)). When a demonstration of nonpoint source reasonable assurance is developed for an impaired water body, additional pollutant allocations for point sources may be allowed provided water quality standards are still attained. If a demonstration of nonpoint source reasonable assurance does not exist, or it is determined that nonpoint source pollutant reduction plans, controls, or best management practices are not feasible, durable, or will not result in the required load reductions, then allocation of greater pollutant loading to point sources cannot occur.

A variety of grants and loans may be available to assist watershed stakeholders with developing and implementing watershed based plans, controls, and practices to meet the required wasteload and load allocations in the TMDL and demonstrate reasonable assurance. Information regarding potential funding sources, cost-share opportunities, and implementation actions that address nonpoint source loading in the Turnback Creek and Tributary to Goose Creek watersheds are provided in the supplemental TMDL Implementation Strategies document available online at dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

14. Public Participation

EPA regulations at 40 CFR 130.7 require that TMDLs be subject to public review. A 45-day public notice period for this TMDL report was scheduled from September 3 through October 18, 2021. No comments were received during this period.

Groups that directly received notice of the public comment period for this TMDL include, but are not limited to:

- Missouri Clean Water Commission;
- Missouri Department of Conservation;
- Southwest Missouri Council of Governments;
- Lawrence, Dade, Christian, and Greene County Soil and Water Conservation Districts;
- County health departments;
- County commissions;
- University of Missouri Extension;
- Missouri Coalition for the Environment;
- Stream Teams United;
- Stream Team volunteers living in or near the watershed; and
- Missouri state legislators representing areas within the watershed.

In addition to those groups directly contacted about the public notice, this TMDL report and an implementation strategies document are posted on the Department's TMDL webpage dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls. All comments received during this period and the Department's responses to those comments are also available at this location.

The Department maintains an email distribution list for notifying subscribers of significant TMDL updates or activities, including public notices and comment periods. Those interested in subscribing to TMDL updates can submit their email address using the online form available at public.govdelivery.com/accounts/MODNR/subscriber/new?topic_id=MODNR_177.

15. Administrative Record and Supporting Documentation

The Department has an administrative record on file for the Turnback Creek and Tributary to Goose Creek *E. coli* TMDL. The record contains plans, studies, and other information on which the TMDL is based. It additionally includes the TMDL implementation strategies document, the public notice announcement, any public comments received, and the Department's responses to those comments. This information is available upon request to the Department at dnr.mo.gov/open-records-sunshine-law-requests. The Department will process any request for information about this TMDL in accordance with Missouri's Sunshine Law (Chapter 610, RSMo) and the Department's administrative policies and procedures governing Sunshine Law requests.

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Appendix A

Turnback Creek and Tributary to Goose Creek (WBIDs 1414 and 1420) *E. coli* data collected by the Lawrence County Health Department (LCHD)

Water Body	Site Description	Sample ID	Site Code	Date	E. coli count/100mL[21]
1414	Turnback Cr. @CR 2025	72959	1414/6.5	4/16/2007	365.0
		72960		5/15/2007	157.0
		72961		5/31/2007	173.0
		72962		6/20/2007	276.0
		72963		7/16/2007	214.0
		72964		8/6/2007	128.0
		220097		5/18/2010	488.4
		220098		6/2/2010	120.1
		220099		6/21/2010	148.3
		220100		7/9/2010	>2419.6
		220101		7/21/2010	325.5
		220102		8/11/2010	143.9
		220103		8/25/2010	93.4
		220104		6/9/2011	90.8
		220105		6/22/2011	49.6
		220106		7/6/2011	95.8
		220107		7/21/2011	110.0
		220108		8/10/2011	86.0
		220109		8/24/2011	73.8
		228654		5/31/2012	>2419.6
		228655		6/20/2012	195.6
		228656		7/11/2012	152.9
		228657		7/19/2012	80.5
		234455		5/20/2013	>2419.6
		234456		6/25/2013	378.4
1414	Turnback Cr. @Paris Springs CA	72950	1414/11.4	5/31/2007	141.0
		72951		6/20/2007	291.0
		72952		7/16/2007	58.0
		72953		8/6/2007	44.0
		72954		6/5/2008	365.0
		72955		6/24/2008	435.0
		72956		7/16/2008	167.0
		72957		8/6/2008	249.0
		72958		8/21/2008	101.0
		220084		5/18/2010	313.0
		220085		6/2/2010	488.4
		220086		6/21/2010	104.3
		220087		7/9/2010	>2419.6

[21] Estimated *E. coli* values reported with greater than (>) are doubled (4,839.6 count/100mL) for assessment determinations.

Water Body	Site Description	Sample ID	Site Code	Date	E. coli count/100mL[21]
		220088		7/21/2010	248.1
		220089		8/11/2010	275.5
1414	Turnback Cr. @Paris Springs CA	220090	1414/11.4	8/25/2010	93.3
		220091		6/9/2011	88.0
		220092		6/22/2011	70.0
		220093		7/6/2011	224.7
		220094		7/21/2011	108.1
		220095		8/10/2011	307.6
		220096		8/24/2011	125.9
		228650		5/31/2012	>2419.6
		228651		6/20/2012	95.9
		228652		7/11/2012	59.8
		228653		7/19/2012	70.3
		234453		5/20/2013	579.4
		234454		6/25/2013	133.4
1420	Trib. to Goose Cr. @CR 2080	72971	1420/0.4	4/16/2007	114
		72972		5/15/2007	435
		72973		5/31/2007	236
		72974		6/20/2007	387
		72975		7/16/2007	727
		72976		8/6/2007	345
		72977		6/5/2008	158
		72978		6/24/2008	308
		72979		7/16/2008	194
		72980		8/6/2008	96
		72981		8/21/2008	48
		72971		4/16/2007	114
		72972		5/15/2007	435
		72973		5/31/2007	236
		72974		6/20/2007	387
		72975		7/16/2007	727

Appendix B

Development of *E. coli* Load Duration Curves

Overview

Load duration curves were used to develop the *E. coli* TMDLs for Turnback Creek and Tributary to Goose Creek. Load duration curves visually display the loading capacity of a water body at all possible flows based on historical flow data and the defined target concentration for each pollutant. For this TMDL a portion of the Turnback Creek loading capacity is assigned to a wasteload allocation. Tributary to Goose Creek currently has no permitted point sources within the watershed boundary, so no portion of the allocation is assigned to the wasteload allocation. For both streams ten percent of the loading capacity is reserved as an explicit margin of safety. The remaining portion of the loading capacities are allocated to nonpoint sources.

Methodology

Load duration curves are based on a flow duration curve developed using a long-term time series of daily flows and a numeric water quality target. Average daily flow data that are representative of the impaired segment are used to develop the flow duration curve. If sufficient flow records for the impaired stream segment are not available, then flow data collected from a gage in a representative watershed may be used, or a flow duration curve can be derived by synthesizing long-term flow data from several gages within the same ecological drainage unit.

To develop a load duration curve, the average daily flow data from a gage or multiple gages that are representative of the impaired reach are used. The flow record should be of sufficient length to be able to calculate percentiles of flow. If a flow record for an impaired stream is not available, then flow data collected from a gage in a representative watershed may be used or a synthetic flow record from several gages can be developed.

For Turnback Creek and Tributary to Goose Creek, flow estimates were area corrected using data measured by USGS stream gage 06918460, located on Turnback Creek above Greenfield, Missouri, from October 16, 1987 through December 3, 2020. Average daily flow values were area corrected using impaired segment watershed drainage area to gage drainage area ratio (Table B1). Figures B1 and B2 present the flow duration curves developed for Turnback Creek and Tributary to Goose Creek.

The *E. coli* TMDLs in Section 7 were developed by converting the whole body contact category A criteria concentration of 126 cfu/100 mL to cfu per day based on the flow duration curves and a conversion factor of 24,465,715 in order to generate the loading capacity in units of cfu/day. [22] Despite the varying load, the target concentration is constant at all flow percentiles and reflects the static nature of the water quality standards. The observed data provided in Appendix A are plotted on the load duration curve graphs in Section 7 to demonstrate the magnitude of load reductions that are needed to meet the TMDL and attain water quality standards.

[22] $Load\ \left(\frac{\text{count}}{\text{day}}\right) = \left[Target\left(\frac{\text{count}}{\text{100ml}}\right)\right] * \left[Flow\ \left(\frac{feet^3}{s}\right)\right] * [Conversion\ Factor]$

Table B1. Information used for developing area corrected flow records[23]

Location:	USGS gage 06918460 drainage area	Turnback Cr. impaired segment drainage area	Trib to Goose Creek impaired segment drainage area
Drainage Area:	252.0 mi^2	135.4 mi^2	4.75 mi^2
Correction Factor:	--	0.54	0.019

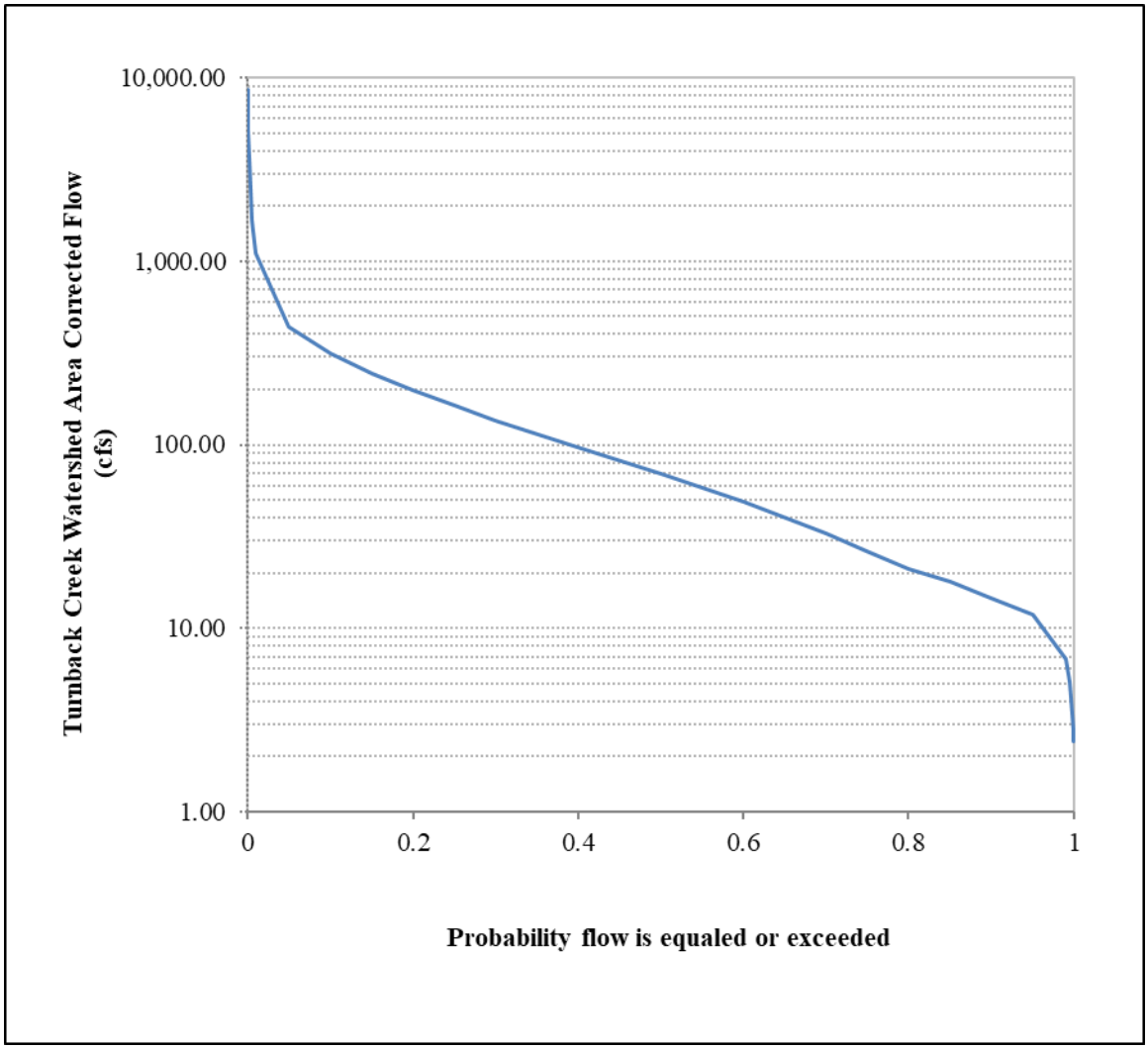

Figure B-1. Turnback Creek Flow Duration Curve

[23] Provisional flow data was not used in the development of the curves.

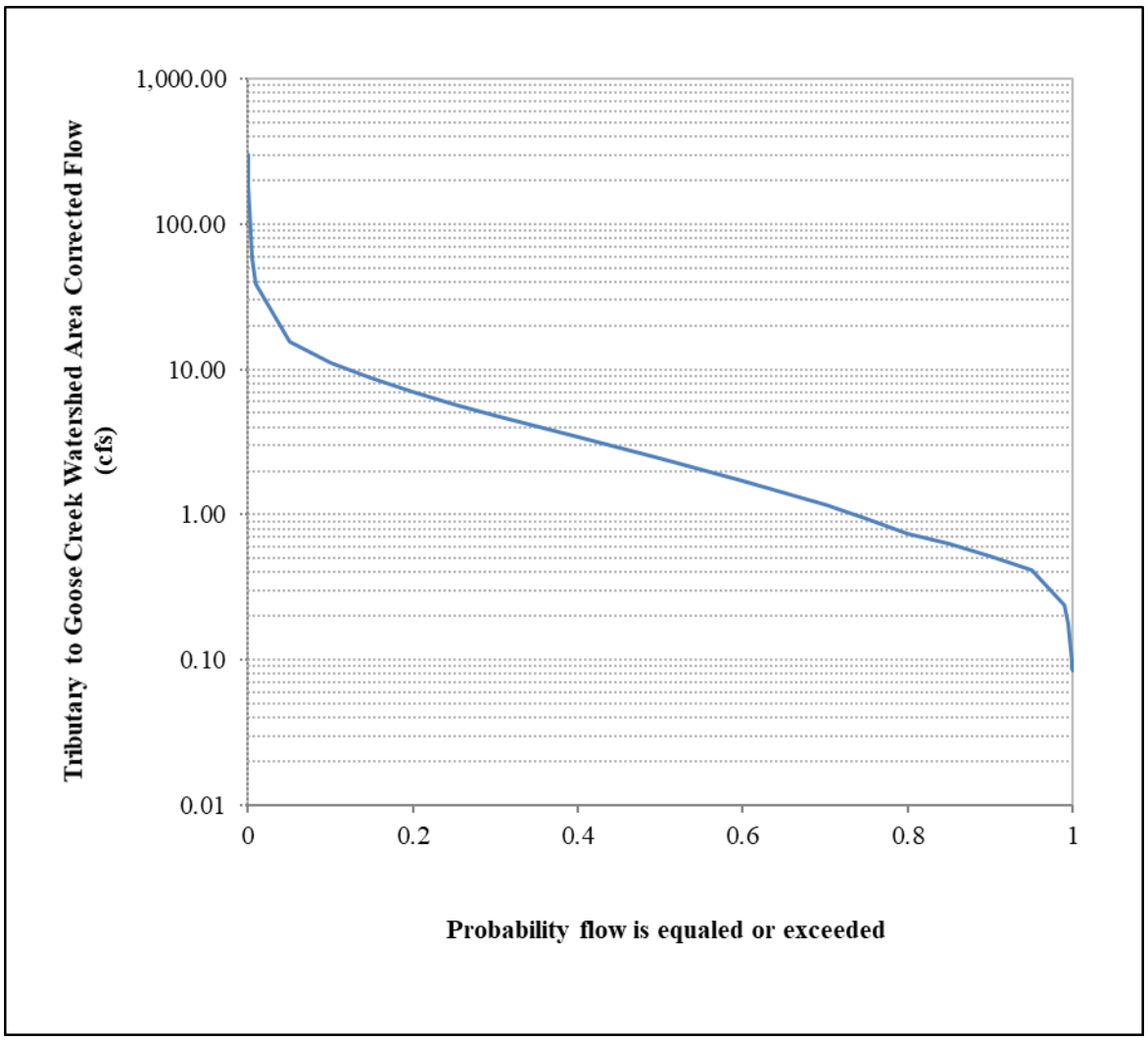

Figure B-2. Tributary to Goose Creek Flow Duration Curve